MINING, PROCESSING, AND USES OF INDIAN MICA

With special reference to the Bihar mica fields

BY

CHAND MULL RAJGARHIA

Mica Producer, Manufacturer, and Exporter; Former Managing Director and Chief Mining Engineer, Indian Mica Supply Co., Ltd., Giridih, India; Vice-President, Bihar Industries Association, Mica Section, Patna, India; President, Mica Factory Owners' Association, Giridih, India; President, Federation of the Mica Associations, Bihar, India; Chairman, International Standards Organization, Secretariat, Mica Sectional Committee; Member, Mining and Geological Institute of India, American Institute of Mining and Metallurgical Engineers; Fellow, Geological, Mining and Metallurgical Society of India; Member, Mica Advisory Committee, Ministry of Works, Mines and Power, Government of India and Export Advisory Council; Ministry of Commerce, Government of India

FOREWORD BY

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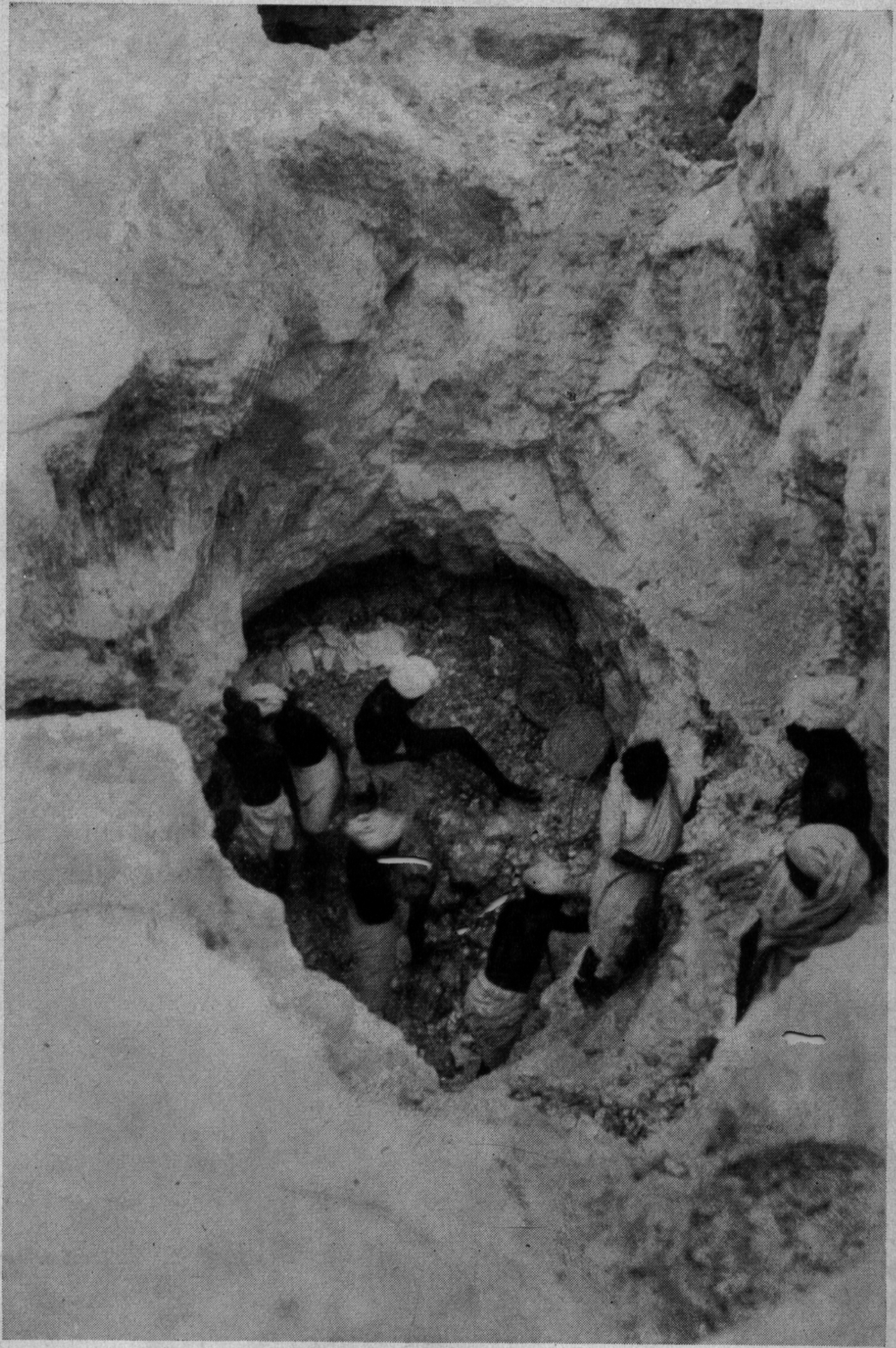

The "surface scratchers."

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Dedicated to the
"SURFACE SCRATCHERS"

Foreword

Mr. Chand Mull Rajgarhia, one of the most important mica producers in Bihar and a leader in the mica trade in India, has asked me to write this foreword for his book "Mining, Processing, and Uses of Indian Mica."

I am very pleased to do this for several reasons, one of which is that I know him very well. I have read over the manuscript in an editorial capacity, chapter by chapter as each was written and then the whole as it was finally put together.

I knew the author's father, Rai Sahib Sunder Mull Rajgarhia, one of the "big" mica producers of twenty-five years ago, when I was closing down the government mica mines at Jorasemar (which had been worked by me on behalf of the Geological Survey of India for His Majesty's Ministry of Munitions, London). Mr. Chand Mull Rajgarhia was born, grew up, and worked among the mica factories and mines of his family in the Hazaribagh District in Bihar. He studied mining at the Indian School of Mines at Dhanbad under Dr. David Penman and for practical training worked as a miner and even as a labourer (on Rs.-/10/- to Rs.2/8/- a day) in various mines in India and Burma. For some years he was chief mining engineer and managing director of the Indian Mica Supply Co., Ltd., of Giridih. Under his care the company was one of the most reliable of the large suppliers during World War II, first, to the government of India (through me in 1940–1942) for the United States government Procurement Division's stock pile and for the Metal Reserve Company, and then to the Joint Mica Mission in India for His Majesty's Government, the government of the United States, and the requirements of the allied countries.

As India produces about 75 per cent of the sheet mica of the world, and as Bihar produces about 60 per cent of the Indian output, it will be recognized that Mr. Chand Mull Rajgarhia's associations are important in the mica world. I can think of no one better qualified by upbringing, by training, and by practical experience in production and trade to express reliable opinions on the search for mica and the finding, processing, and marketing aspects of the Bihar mica industry.

The author has expressed his disappointment that there should be so trifling a demand for mica in the industries of India, and his surprise that the immense industrialization now affecting India does not appear to include any branch that will utilize Indian mica on large scale. It is to be hoped that this book will clarify this subject so that industrialists of India may review their opportunities and help develop the means of using more mica in India's industrial expansion.

Mr. Chand Mull Rajgarhia has shown only too well the greater element of chance in obtaining mica than exists in most other forms of mining. He has dealt very skillfully with the subject of standardization of mica and the marketing and uses of mica; he has touched very deftly on the problems of mining leases, the unsatisfactoriness of labour, and certain environmental and occupational diseases associated with mica mining and has provided useful new information. His treatment of statistical information on mica is very valuable.

The author has hinted in his book at some lack of complete agreement among the producers of mica in Bihar, that there are even opposing interests, and that at least on occasion in their relations with the Joint Mica Mission, for example, some producers have shown themselves somewhat contradictory in their attitude. When I was entrusted with the procurement of mica for the American stock pile, from surplus mica in stock, I believe His Majesty's Government had already been advised that such quantities and qualities of mica as were desired by the Government of the United States were unprocurable in the time indicated since the mica still lay underground and would have to be mined and processed. It may be interesting to state that I was obliged to offer for sale nearly three times the required quantity before the mica was found acceptable at the price offered. It is true that some of the mica was reoffered after a refusal for "price out of line," but the offers were quickly made and all were for surplus mica from stock or from very early processing.

This shows that in the advice tendered to His Majesty's Government by the Bihar dealers (as the source of advice), there must have been a lack of agreement and understanding among the Bihar producers, and a correct representation of the actual supply position was not made at a very critical time. In this connection I must record that, without the assistance of such Indian firms as Chaturam Horilram of Jhumri-Telaiya (near Kodarma), the Indian Mica Supply Co., Ltd., of Giridih, and other smaller producers, it would have been quite impossible for me to have offered stock-pile mica to the American government. In the case of one item, which it seemed almost impossible to procure at the right price, the Indian Mica Supply Co., Ltd., provided roughly 80 per cent of the quantity required, but they and the other firm named helped on more than one occasion to provide very large quantities for quick delivery when it was impossible to get appreciable quantities of material from anyone else at the prices acceptable in America.

In the last three chapters of the book—Mica Piracy, Conservation of Mica, and Conclusion—there is much of interest because the author very definitely shows how he disagrees with other parties in the Bihar mica industry. Mica piracy is a modern and polite expression for illicit dealing in mica or, as I used to call it, mica theft. In the opinion of Mr. Rajgarhia this is another subject which has been unnecessarily stressed as regards both the volume and the value of the mica losses incurred as a result of thefts of illicit dealing. And it is his opinion that until there is supporting statistical information of a very clear and complete type it will be impossible to say if losses from mica thefts are larger for the mica industry than, say, losses from burglaries are to a community, but I would add that continuous claims of very large losses of mica, unsupported by good evidence, may be taken with a large measure of salt. These are probably due to inefficient management or are imaginary.

The author has shown correctly that mechanization is a means of providing better facilities for mining by drilling, pumping, hoisting, etc., as the mines go deeper or become larger. The mechanical appliances alone, even under good management, can never take the place of a well-trained staff under a really skillful and energetic manager. It is better practice to have men trained in the mica mines, as apprentices, so to say, and not to bring in men with diplomas and degrees for underground work. Graduates usually leave after getting some practical experience, but this is to be expected, since very highly educated men are not essential for the work, but the "all-the-time" type of man is required in mica mining. In this I must say I agree with Mr. Rajgarhia up to a point. I would have the better educated man if I could keep him, but this would depend on the market price of the mica and the wages to be paid, allowing for a margin of profit.

The author has expressed the opinion that the *upperchella* workers, or "surface scratchers," as they are sometimes called, have given valuable aid to the mica-mining industry, since they have acted in the role that prospectors fill in the exploration of gold and other minerals. There can be no question that Mr. Rajgarhia is correct. These men have painfully searched for and found hidden pegmatites and developed them at their own risk and expense usually, but, as the mine or quarry has gone deeper and water difficulties have had to be dealt with, or other unproductive expenses have had to be faced, they have not been able to meet them. As a result, the mines have been abandoned or acquired by some larger mica-mine operator who had the means to step in at the right time. I think this is the history of almost every important mica mine now working in Bihar.

Among his conclusions the author has again referred to the great element of chance in mica mining, and he considers that, in view of the state of the industry, with opposing factions on the one hand and rising costs on the other, the time has come for a searching discussion among the members of the industry to set things right and to secure better or more satisfactory prices. I am thoroughly in agreement with the view that the Indian mica industry is in need of a complete overhauling and that the question of price is fundamental. As the author has stated in his chapter Marketing of Mica, the value of the mica in any given apparatus is about in the same proportion as the salt for a good dinner.

It is to be remembered that practically all this material (and mica is recognized as a strategic mineral in the United Kingdom and the United States, where their domestic supplies are inadequate), is *exported* from India in a more or less raw condition. It is a mineral of national importance and can be regarded as a "key" industry. Therefore it deserved the investigation which the government of India decided to give the mica industry by a specially selected Mica Enquiry Committee with assessors and technical advisers. This committee has submitted its report.

Mr. Rajgarhia has referred to some very interesting research work on the testing of mica, for its dielectric and other properties, which has been done since 1942 in the Bell Laboratories in the United States and which has led to the introduction of useful test apparatus. In this connection I feel obliged to disclose a little of the work which was attempted in India and which is known to very few people, even in the Indian mica industry; these few, however, include Sir Evan Jenkins (as Secretary of the Department of Supply, Government of India) and probably also Sir Ramaswamy Mudalier, who was anxious that Madras as well as Bihar should market mica through our official purchases for the stock pile. At that time, 1941, American buying through me did not include Madras green muscovite mica, because the Americans were led to believe that Madras mica was inferior to that from Bihar. As this had already appeared unlikely to me and as I wanted to get the mica requested as quickly as possible, I decided to test equivalent qualities of mica from Bihar and Madras.

The necessary tests, for dielectric strength, etc., were carried out for me at the University College of Science, Calcutta, after the firm of Chaturam Horilram had provided funds for the equipment that was specially required. Samples of mica were obtained through the government inspectors at Nellore and Calcutta for Madras and Bihar, respectively, although they were not told more than to supply typical mica of certain qualities. The results showed that there was practically no difference in the equivalent qualities from Bihar and Madras, and also that there was very little difference in the qualities from clear and slightly stained down to stained, in both cases. Some tests on radio frequency suggest that green muscovite behaves differently from ruby muscovite, but tests conducted on both types for other characteristics show close similarity for equivalent qualities, with perhaps some advantage in favor of ruby mica.

Furthermore, it was evident that the scratch down the film of splitting reduced the strength (under high-tension electric charge) by 40 to 50 per cent along the line of the knife mark. This last detail was expected, as it seemed obvious that a steel point must cut the mica and reduce its thickness along the scratch. The other results were in no manner a surprise. Indeed, in one or two tests the Madras mica proved better than its Bengal equivalent.

With the results of the tests in my possession (and more representative samples from Madras and Bihar available) I approached the American Consul General in Calcutta (then Mr. Thomas Murray Wilson), and, with the assistance of the Vice-consul (then Mr. Morris Swift Hazelton), samples were dispatched by air to the United States to be tested by some well-recognized institution in America.

A few months later at a reception in Calcutta introducing Mr. J. E. Waddell, representative of the Metal Reserve Company, to Sir Evan Jenkins, we were told that a cable had arrived that day from the United States to the effect that the Metal Reserve Company was to buy Madras mica in the same manner as Bihar mica. It is of course possible that the investigations carried out at the Bell Laboratories were quite independently conceived and conducted, but it is interesting that they were carried out at the same time that we were working at the problem. Indeed, I would go further and say there was not really any problem, but the purpose of the investigation was to establish proof in India of what we thought and then to have confirmatory tests.

We have also done some geophysical work in India with the assistance of the geodetic branch of the Geological Survey of India, using the resistivity method for finding "anomalies," but the results in waterlogged ground were not satisfactory, and I believe the Geological Survey of India will consider another line of approach in the search for hidden mica pegmatites. There is no question that there is very great scope for scientific research in the exploration of mica deposits, as well as in the processing and utilization of mica, but such work must be done in experiment and field surveys by actually qualified men and can never be solved by the theoretical exposition of those who are not thoroughly familiar with the occurrence of mica pegmatites and not fully efficient in geophysical methods by experience.

Since I have had a service of thirty-two years with the Geological Survey and another two years in touch with the position of the mineral industry of India, it may not come amiss if I say that the industrialization that is developing in India does not appear to have given enough attention to several details, including mica.

This appears to me to be due to a curious feature which I have only noticed well in the last three years. The directional progress of this industrialization depends on the degree to which the industrialists are convinced of the success of an enterprise in which they are to be the financing force and controlling authority. If the sons of the bigger industrialists in India were, as a matter of training, brought up in a technical atmosphere, as Mr. Chand Mull Rajgarhia has fortunately been, then I am sure that many new and important developments in India's industrialization would be taken up and pushed to success, because these young men would know what they were doing and would be fully trusted by their elders in such technical matters as the older people, who must secure their information from paid experts unacquainted with their principal's personal affairs, cannot know.

It is quite erroneous to think that India is well endowed as regards mineral wealth. The country's minerals in most cases pose the problem of finding new processes that will make full use of the resources. This needs hard and original work and will not be done successfully by trying to copy foreign methods that are used for very similar but not quite the same materials.

In the case of mica the problem is exceedingly simple and will be solved by technical as well as business ability, after securing accurate information of the requirements and specifications of foreign consumers for the mica they need. Thus it is fortunate that Mr. Rajgarhia proceeded to the United Kingdom and to the United States as a member of an official mission from the government of India to deal with certain mica questions relating to the gradual releasing of mica stocked in these countries. Mr. Rajgarhia's knowledge and experience were utilized by the Indian Mica Enquiry Committee (see Report of the Mica Enquiry Committee, 1944–1945, published in 1946) as an assessor. His visits to the United Kingdom and to the United States enabled him to make valuable contacts with mica brokers and consumers in both countries, as well as visits to various works where micanite products are manufactured for various branches of the electrical industry. In this way he has acquired a unique knowledge of the uses of Indian mica and his remarks in this respect must be considered highly authoritative. Mr. Chand Mull Rajgarhia will give of his best for his country and his country's government. His book will, I know, prove useful to many and ultimately receive the full attention that it deserves.

CYRIL S. FOX

Preface

When the Mica Enquiry Committee (on which I served as an assessor) was set up to investigate a number of controversial problems confronting the Indian mica industry, it found a paucity of dependable literature on the various phases of the mica industry. This was keenly felt, by the committee, as well as by the trade. Outside of a few sketchy pamphlets published by the Geological Survey of India, the only book available is "Handbook of Mica" by Mr. Ramani Ranjan Choudhury, which is a valuable contribution to the trade from the commercial point of view. But sufficient literature dealing with the technical side of the industry was and is still lacking.

The Enquiry Committee consisted of Mr. Justice D. E. Rueben, I.C.S., a judge of the Patna High Court in the province of Bihar, India, as chairman; Mr. Md. Ismail Saheb, a hides and skins merchant from Madras; and Lala Gurusharan Lall, C.I.E., who is interested in a number of industries other than mica.

To secure unbiased consideration, the government of India purposely chose laymen for the chairman and members of the committee. It was necessary, therefore, to help these respective members understand the problems of the mica-mining industry such as geology, characteristics of mica, mining, processing, etc. This required the writing of a comprehensive memorandum that was entrusted to me by a section of the trade.

The origin of this book is a direct result of the memorandum that I wrote for the benefit of the committee on which I was asked to serve as an assessor. When the memorandum was circulated amongst my business friends in Bihar, Madras, and Rajputana, the demand increased from all quarters to such an extent that I announced that I would undertake to write a book that I have entitled "Mining, Processing, and Uses of Indian Mica."

I hope I have succeeded in giving a clear description of all aspects of the Indian mica industry and its problems. Likewise, I have endeavoured to the best of my ability to place before my readers all the essentials that exist and those which are lacking, with equal frankness and without exaggeration. I hope the facts reported in this book will give an idea of the wide extent to which this peculiar and speculative industry is regimented by natural conditions.

That is the story of the book. I should be lacking in frankness, however, if I did not refer to the part that current controversy of an acrimonious kind played in increasing my zeal for its publication. But I have conscientiously tried to keep an open mind; and the views I have expressed here are honestly held. All that I have said in the following pages is just what my eyes have been seeing and my heart has been feeling for more than a decade about the various aspects and problems of the Indian mica industry. I have no wish to impose my views on my readers, nor do I intend to cling to those views obstinately in the face of facts and considerations that argue differently. I have stressed the undeveloped scientific and practical knowledge that vitally concerns the Indian mica industry. No book on this subject can possibly be the definitive word. Any constructive criticism will be most cordially welcome, and I shall not be lacking in any effort to profit by it and to incorporate the results in a later publication, need for which is borne in on me more strongly as I complete this work. I hope, too, that by the time I produce a second volume, the fires of current controversial problems will have been completely extinguished.

Since this book is chiefly meant to educate and enlighten people concerned with the production of mica (specially in India), a great deal of elementary matter has been included in some chapters, particularly the one devoted to mining, which qualified mining engineers may feel to be somewhat irritatingly superfluous. I am conscious of this. And I am conscious also of the fact that, in writing the chapter on Uses of Mica, I have no authority to consider myself an outstanding expert. My activities have been strictly confined to the production of mica in India, where little progress has been made in finding new uses for this precious gift of nature.

Virtually all that India produces is exported to foreign markets, to supply the electrotechnical industries of the world.

My visit to the United Kingdom in 1945 as a representative on the mica delegation, which was sent to London by the government of India and sponsored by Sir H. C. Prior, I.C.S., to arrive at an agreement with the United Kingdom government after the recent world war, and my visit to the United States thereafter, plus a subsequent visit to the European continent and the United States in late 1947, gave me the opportunity to contact many eminent consumers of mica. I was also able to visit the factories and works fabricating or consuming mica as a finished product. I had access to the information and literatures collected by them from these sources. All this helped me to enlarge the chapter on uses and to expand upon the relation of the various commercial mica groups and their vast field of utilities and what each group contributes to the economic aspect of the Indian mica trade.

Recently conditions in India have changed considerably, and have brought higher production costs and increased commodity prices. These developments along with a greater demand for mica have been keenly felt during the last year. References made within the body of this book should be treated as those in force during 1947, 1948, and 1949, and the above-mentioned changes do not affect the main subjects under discussion in the various chapters.

CHAND MULL RAJGARHIA

NOTE: Since this book will have wide circulation in India, readers will find some uses of British and Indian terminology which are explained in a glossary on page 344.

Acknowledgments

The reader will not feel surprised at the long list of men to whom I acknowledge my indebtedness in different ways. I wish to express my debt of gratitude to all my friends abroad, particularly Messrs. A. Blackstock and J. Smith of Langlay London Ltd., London; Sir Arthur P. M. Fleming, and Mr. A. R. Dunton of The Metropolitan Vickers, Manchester, England; Messrs. William H. Banks, Jr., and R. S. Thayer of Macallen Company, Boston, U.S.A.; Mr. Joseph J. Long of Ford Radio & Mica Corp., Brooklyn, U.S.A.; Mr. Julius Buffalino of Huse-Liberty Mica Co., Boston, U.S.A.; Mr. J. W. Canter of Minerals & Insulation Corp., New York, U.S.A.; Messrs. Glenn Vance and Glenn L. Powers of Perfection Mica Co., Chicago, U.S.A.; the various personnels of General Electric Co., Schenectady, U.S.A., and Micafil Ltd., Zurich-Altstetten, Switzerland; Andre Netter, Louis Guilbaud, and François Roussel of Société Anonyme Sciama, Paris, France; Messrs. Dott. Ing. Mario Carlevaro and Olivo Busonero of Stabilimento Electrotecnico "Ansaldo" S. A., Genova-Cornigliano, Italy; Mr. Rognoni F. of Milano, Italy; Mr. Giorgio Negri of Giorgio Negri & Co., Milano, Italy; Mr. C. H. Marell, Civilgeniör of Aktiebolaget Galco, Stockholm, Sweden; Messrs. Sigurd Barkmen and E. G. Malmlöw of Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden. They accorded me a most cordial reception. They showed very keen interest in explaining to me the important uses of mica and furnished me with all the available literature and illustrations on the subject contained in their catalogues and manuals.

I am also grateful to Mr. C. J. Schwab of Schwab Bros. Corp., New York, U.S.A.; Mr. F. D. Pitts of F. D. Pitts Company, Boston, U.S.A.; Mr. P. C. Hart of Hart Maylard & Co., London, England; Mr. S. K. Dutt of Indian Produce Supply Co., London, England; and Mr. G. Felice Checcacci of Rapallo, Italy; who spared no efforts to make me feel perfectly at home during my stay in their respective countries and kindly arranged my visits to most of the above concerns using or fabricating mica.

I am also grateful for the knowledge gained about recent uses of mica and mica fabrication from Mr. S. A. Montague of the Spruce Pine Mica Company, Spruce Pine, N.C., U.S.A.

My sincerest gratitude is also due to Sir Cyril S. Fox, who has written a foreword and who very kindly edited this book. His help in its completion was invaluable. No less was the help I received in the various stages of the book's preparation from Mr. P. R. Srinivas of the Indian Finance and Mr. H. C. Chellson of *Engineering and Mining Journal* and *Coal Age,* New York, in final editing and preparation for production.

Messrs. E. Watson of the Chrestien Mica Industries Ltd. (formerly F. F. Chrestien Ltd.); R. A. Hart of Hart Maylard & Co., London, England; N. C. Choudhury, Secretary of the Mica Factory Owners' Association, Giridih; K. M. Ellahi, President of the Bihar & Orissa Mica Association, Giridih Chapal Bhattacharjee, and Dr. P. B. Gupta, both labour leaders, also rendered me immense assistance by reviewing the manuscripts and expressing their critical views on the same, and I am deeply obliged to all of them.

Dr. H. C. Chatterjee of the State Railway Collieries, Giridih, was of great assistance in studying and writing the chapter on Labour and the Occupational Diseases. I must also acknowledge the indirect help given by the secretaries of my various departments, and the splendid cooperation and assistance of my personal secretary, G. V. Raghavan. But for his alertness and readiness at all times, the book could not have been completed in the manner it has been.

Last but not least my everlasting gratitude is to the "surface scratchers" who laid the foundation stone of this industry. They are still "Doctors" of the art of prospecting mica deposits. To them this first work of mine on mica has been dedicated.

CHAND MULL RAJGARHIA

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CHAPTER 1

Mica, Nature's Most Useful Curiosity

To those conversant with the mythological stories of India, *Abrak* and *Abhra,* the Indian names for mica, are quite familiar words. Hindu classical writers imagined mica to be a sort of petrified lightning flash, and the two Hindustani names mentioned above, connoting clouds and heaven, are evidence that the lustrous character of mica was attributed to its celestial origin, which again is corroborated by the common use of *Vajra* (thunderbolt) as one of its names.* In the prehistoric days of Satyayuga, when there was war between the Gods and the Demons, it is supposed that Indra, the King of the Gods, lifted his *Vajra* to kill the enemy. Flashes of lightning spread throughout the entire length and breadth of the sky, whilst sparks which fell on the mountains were arrested in them in the form of mica.

The ancient Hindu writers classified mica in four varieties: the *Brahmans,* white and colourless; the *Khatriyas,* red-tinted; the *Vaisyas,* yellow; and the *Sudras,* black. According to the medical classification, the different varieties were identified by their different behavior under fire. The *Pinaka* variety when thrown into the fire split into thin laminae and if swallowed accidentally produced leprosy; while the *Dadura* when heated emitted a noise like that of a croaking frog and was deadly poisonous. The *Naga* variety, as is indicated by the name itself, produced a hissing sound like that of a snake when thrown into fire and caused fistula if swallowed. The one called *Vajra* was not affected by fire and was considered to be the best kind. This particular variety is supposed to have been used for medicinal purposes, for removing the infirmities of age, and for preventing untimely death.

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* The historical facts have been gathered mostly from "Mica, Its History, Production and Utilization," by Mr. H. Zeitler, 1913, and another reference to mica by Sir Thomas Holland, of the Indian Geological Survey in 1902, "Mica Deposits of India."

From the above facts, it is evident that in ancient India mica was mainly used for medicinal purposes. The Indian druggists purposely complicated the process of preparing medicines from mica with a view to preventing amateurish imitations. Not only were the processes complicated, but they were also very long and tedious.

Even today the *Kavirajes* (Hindu physicians) use appreciable quantities of biotite (iron magnesium mica), locally known as *Rama Abrak*, for the preparation of *Abhra Bhasma,* meaning "fused powder of mica." If the said *Abhra Bhasma* is to be prepared strictly according to the process prescribed by *Aurveda Sastra* (the ancient Hindu medical science), the powdered bulk of crude biotite has to be fused with a number of reagents one thousand times to attain perfection. But it should be fused at least one hundred times before it could be administered as a medicine in the human system. However, the effect of such powder is said to be proportional to the number of times it is treated with fire. The average price of such *Abhra Bhasma* fused one hundred times is about Rs.800/- per pound and it is said to take at least four months to prepare it. Such *Bhasma* or ash prepared strictly in accordance with the principles prescribed by the *Shastras* (*i.e.,* by fusing it one thousand times) is regarded as invaluable. It is used as a tonic for general debility, nose, throat, ear, and brain diseases, all kinds of abscesses, dyspepsia, and various other diseases. The other varieties, which could not possibly be made use of for the preparation of medicines, were used for decorative purposes, lantern panes, paintings, etc.

Mica is said to have been employed by Greeks and Romans in the same manner as in India. According to Mr. H. Zeitler, in prehistoric times, mica was known to the red Indians of America and was employed by them for many purposes. On account of its iridescence it was used for the purpose of decoration and its reflecting property rendered it usable as a mirror. As revealed by the remains unearthed in the state of Ohio in the United States, considerable quantities of mica were buried with the dead. The red Indians had a peculiar method of obtaining mica, and one which was well known a century ago in India. A great fire was started close to the rock containing mica, and when the stone got red-hot, the fire was withdrawn and the rock suddenly cooled by water poured over it. Owing to the sudden change in temperature, the rock cracked, enabling the red Indians to separate the mica books from the country rock.

The name Moscow or Muscovia has long been associated with Russian mica; hence the name "muscovite." In Russia also, mica was used for medicinal purposes. It is believed that fire changed mica into white powder, which was used by women to whiten their faces and to remove wrinkles. Moreover, mica was universally used as a substitute for glass. In Russia the ikon pictures were covered with thin sheets of mica so that they would not be damaged when kissed by the people, according to custom.

In Germany, the use of mica was far less extensive. Very small quantities were employed by the toymakers of Nuremberg to serve instead of glass, and the waste flakes of mica were sprinkled over carpets and draperies, which were regarded as fashionable when thus decorated. Mica strips were used for mounting microscopic objects and also for sealing zoological objects preserved in spirits.

However, in ancient times the main use of mica in countries other than India was mostly limited to serve the purpose of glass. With the evolution and rapid growth of the glass industry the consumption of mica as a substitute for glass declined. At the same time, new appliances gradually developed requiring considerable quantities of mica, which in fact may be regarded as the foundation of the present-day mica industry. Some time in the middle of the nineteenth century, the continuously burning stove was developed in the United States and was introduced into Germany in 1870 or thereabouts. To be able to observe the fire in the stove and to regulate it conveniently, it became necessary to insert a number of small mica windows in the stove door, and the large-scale manufacture of such stoves in Germany absorbed considerable quantities of mica. At about the same time, considerable improvements were made in the burners of the gaslighting industry, which also warranted the use of mica sheets in considerable quantities for surrounding the flame.

Before the invention of refractory Jena glass, mica chimneys were the only possible means of enclosing the flame of lamps, particularly of the incandescent gas lamps. The material had to possess a high heat-resisting capacity and had to be capable of withstanding the rapid and wide changes of temperature that usually take place during the lighting and extinguishing of a lamp. In the absence of any other material, mica satisfied best of all the aforesaid requirements. In short, before the electrical age, the chief uses of mica were in lamp chimneys and shades, stove windows, and furnace peep-hole covers, and its minor uses were for lubrication and decorative purposes.

Though all these uses still continue, they have sunk into insignificance in comparison with mica's insulator and dielectric uses in the electrical world.* Before the invention of micanite, or built-up mica, only pieces larger than 6 sq. in. (grade 4) were in demand, while a major portion of the mined bulk had to be dumped at the mines as useless mica. But with the increase in the size of electrical units like generators and motors, the problem of insulation became more and more acute, since any other material such as glass or porcelain (among the finest insulators) could not possibly be used where there was pressure or vibration, where sudden changes in the temperature were encountered, or where very thin flexible sections were needed. Other insulators like paper, silk, vulcanized fibers, or asbestos, when impregnated with asphalt, oil, or paraffin, as is necessary to close the interstices between fibers, quickly charred or burned. Sheet mica was the only substance that answered all requirements. But the development of applied electricity was considerably threatened by the difficulty involved in procuring mica in large enough sheets to extend its use to the many parts of generators, motors, transformers, etc., which need unfailing insulation.

The problem was finally solved by the invention of micanite, or built-up mica, which today has become the most important electrical insulator. This was the invention of an Englishman, Mr. Arthur H. S. Dyer, and was publicly described by Mr. Edward P. Thompson at a meeting of the American Institute of Electrical Engineers held in December, 1892.

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* Facts relating to the importance of mica in the electrical age have been taken mostly from the United States Tariff Commission, "The Mica Industry," *Report* 130, Second Series, Government Printing Office, Washington, D.C., 1938.

This invention enabled the use of thin splittings prepared from the smaller size mica usually thrown away as waste, by building them with a suitable binder into plates or boards (commonly known as "built-up mica sheets" or "micanite plates") to any desired size and thickness. Thus the demand for mica splittings first arose.* In India, the manufacture of mica splittings was first introduced about the year 1895, when Mr. Franklin Brooks of the Mica Insulator Co. of New York, Mr. H. S. Munsell of Munsell and Co. of New York, and Mr. O. S. Fillion of Ottawa visited India and were entertained by Mr. F. F. Chrestien at his Tisri mica factory. These men found enormous dumps of mica lying over the mining and factory area, which contained small but sound and splittable pieces of mica. Mr. Munsell is said to have trained a few boys and girls in the locality in the art of splitting mica.

With the march of time, the demand for such mica splittings increased and popularized the manufacture of splittings in the mica area of Bihar to such an extent that today practically the entire population of all the villages, especially that surrounding the mica-manufacturing centers, possesses an amazing mastery of the art of splitting. In the absence of any separate statistics with regard to the export from India of splittings prior to the year 1921, no clear picture of the growth of this splitting industry can be given. The figures available from 1921, however, sufficiently prove the colossal increase in the volume of business effected between the years 1921 and 1937. In 1921, the total quantity of splittings exported from India was 17,651 cwt., which gradually increased to 267,340 cwt. in 1937. This increase is the direct result of the invention of micanite. It is therefore no exaggeration to say that Indian mica owes to micanite whatever industrial character it has today. For, with a demand for only grades 4 and up, the industry would have died a natural death, once the easily accessible rich surface deposits were exhausted and the cost of production increased with the necessity of mining at a greater depth.

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*R. R. Chowdhury, "Handbook of Mica," Thacker, Spink & Co., Ltd., Calcutta, 1939; Chemical Publishing Company, Brooklyn, New York, 1941.

But unfortunately for the mica industry, in spite of this invaluable contribution of mica splittings to the success of applied electricity, the prices available for these splittings (especially the smaller grades of loose splittings) are even today very low, particularly in view of the colossal amount of labour involved in their preparation. This can be attributed only to the very low levels at which mica prices were first quoted, when the basic block used for such splittings was easily recoverable from the surface deposits and the costs of production were very low. The sale of splittings in those days amounted to a little extra sweetening of the project. Consequently, it did not lead the premiers to ask for better prices.

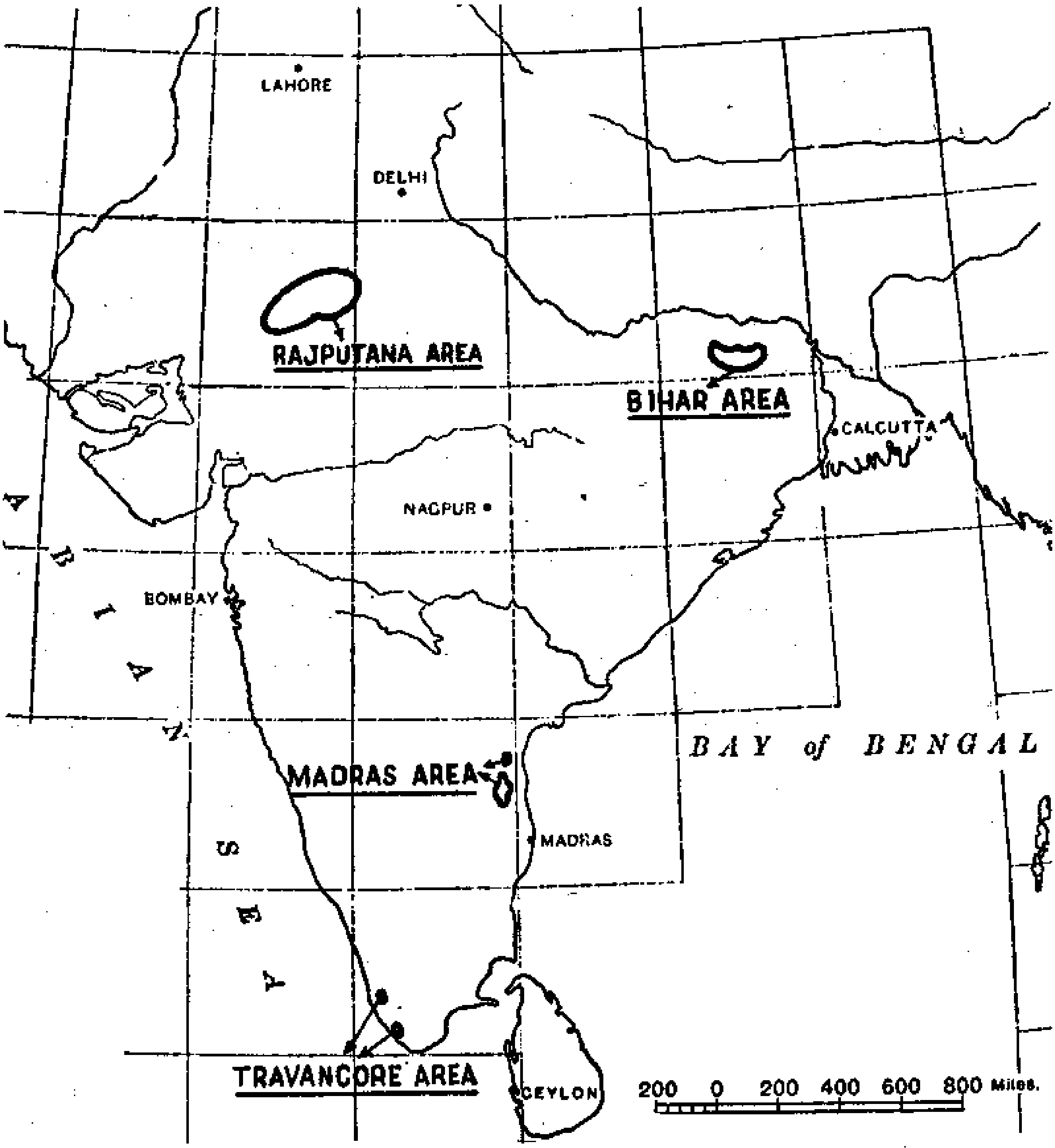
Therefore the splitting industry from the standpoint of reasonable prices was born as a rickety child and its infantile disabilities have persisted to this day.

Later on, with the rapid developments in the electrical world, which gave birth to useful appliances like radios, condensers, etc., the smaller size block mica also found a demand.

Today the requirements of mica in the electrical world are met principally by India, Canada, Rhodesia, Tanganyika, Australia, Union of South Africa, the United States, Madagascar, Argentina, Brazil, Norway, Korea, and Guatemala. But as far as muscovite mica is concerned, India produces practically 80 per cent of the world's total output.

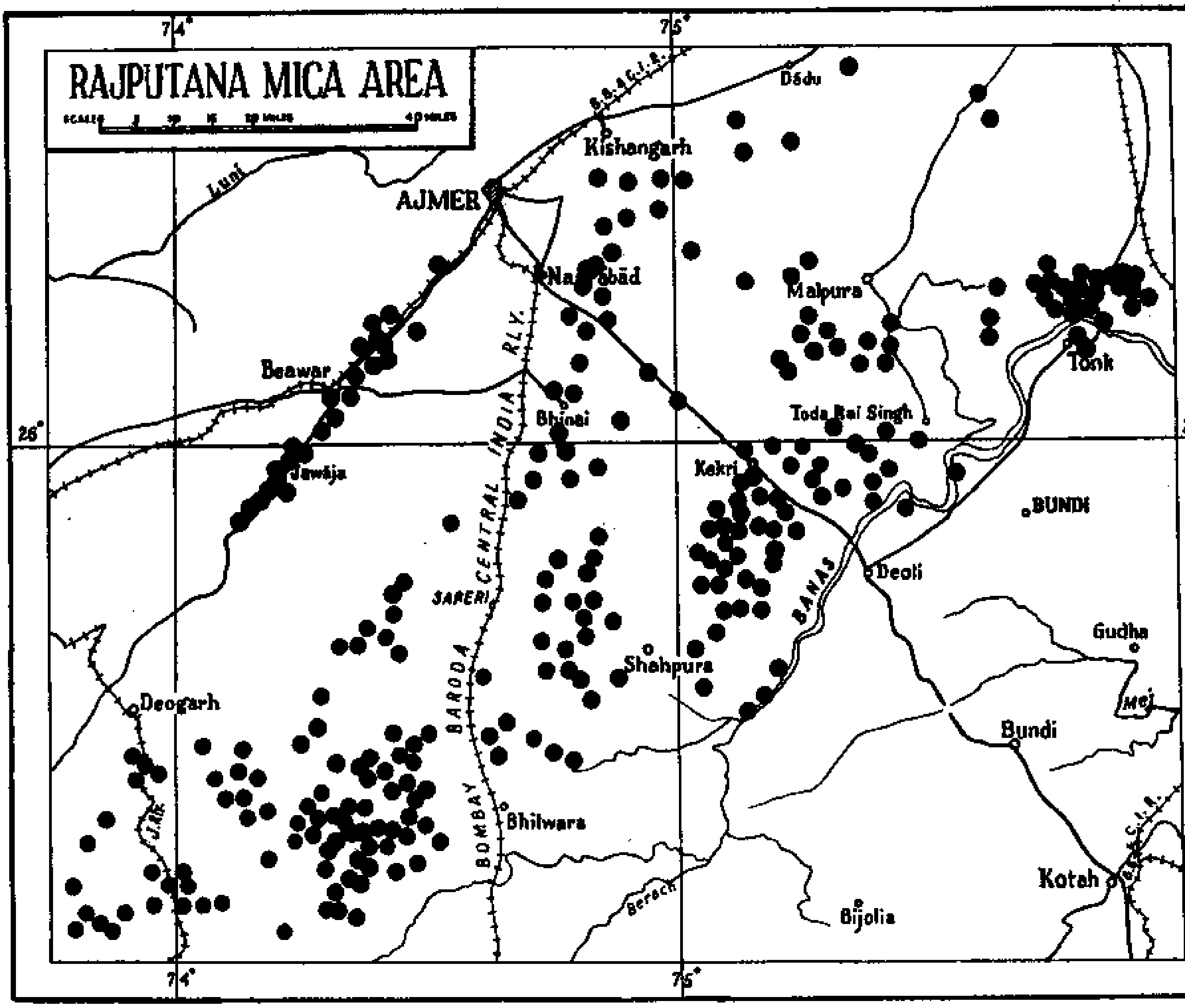
In India, mica is found mainly in Bihar, Rajputana, and Madras, though the occurrence of mica-bearing pegmatites in the Central Provinces, Nepal, and other provinces has been reported. Rajputana has been contributing considerable quantities to the total production of India since 1938, though it also has a small mica-mining industry of very long standing. At one time, pioneers and veterans like F. F. Chrestien & Co., Ltd., and J. S. Mull & Co. tried their luck in the Rajputana fields; but mica has an inscrutable way of choosing its own favourites. These concerns failed in spite of their best efforts, while in recent years people with no experience in mica mining succeeded in discovering exceptionally rich deposits in Udaipur State in Rajputana. In 1939 to a total Indian production of 154,000 cwt. of S.D.B. (sickle dressed block) Rajputana contributed about 29,000 cwt., and the amount has increased considerably since that time.

The average size and quality of Rajputana mica is undoubtedly superior to that of the average bulk of Bihar mica, but an unfortunate lack of flatness in the average production of Rajputana has affected its commercial value very seriously. Practically the entire production of Rajputana is bought by Bihar manufacturers and processed in Bihar. Hence no mica is directly exported to foreign countries from Rajputana.

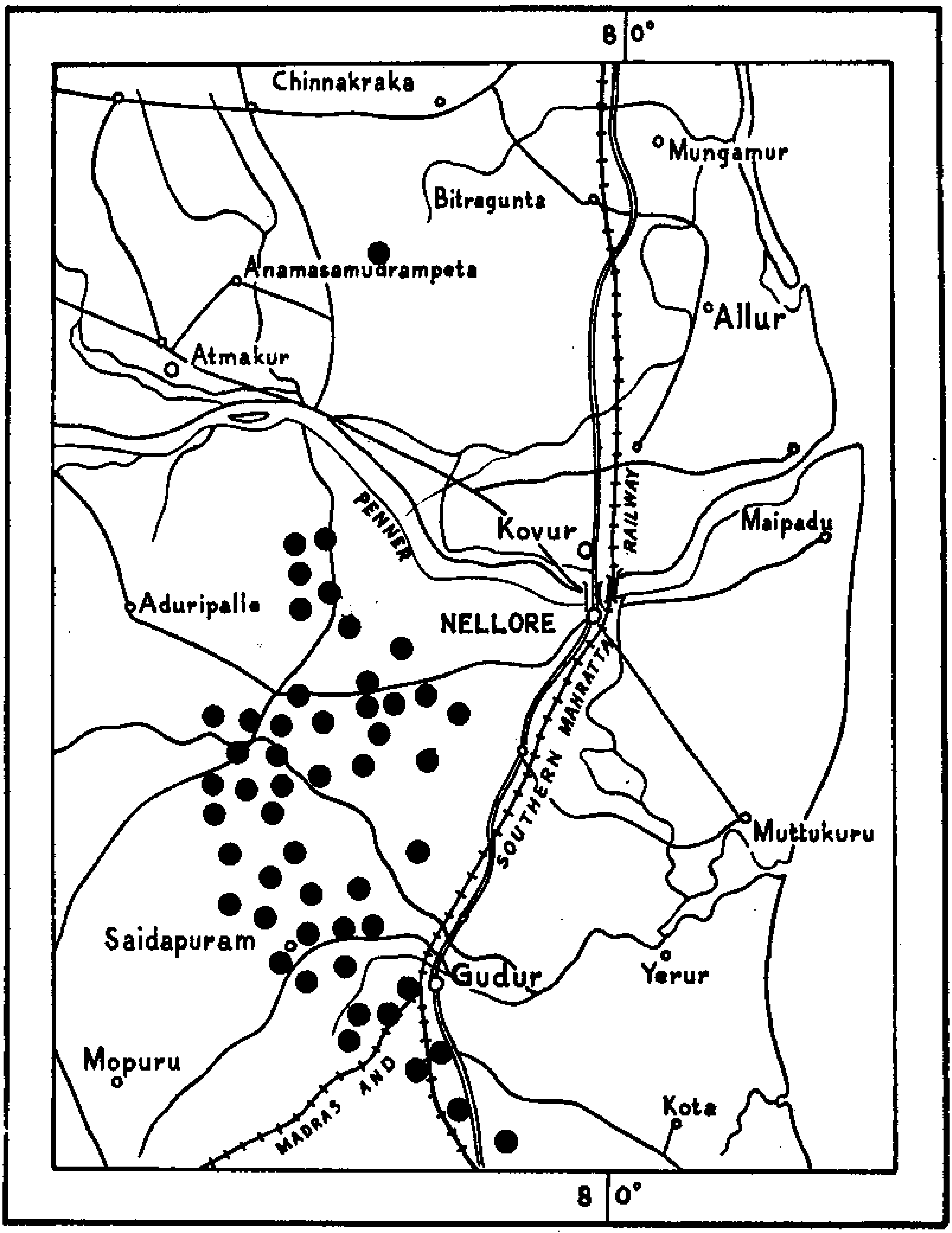


Madras also has a very old and well-established mica industry. The bulk of the production of Madras predominates in black spotted mica, which is technically known as "electrical" mica. Since the flatness is a remarkable feature of the average production of Madras

Madras spotted always finds a preference in the foreign market over Bihar or Rajputana spotted. The basic colour of such spotted mica is generally green. From the bulk produced by mines yielding only spotted mica, some percentage of green clear mica is also obtained while rifting or cleaving the crude books.



Besides green mica, Madras produces a fairly appreciable quantity of ruby mica. Since some mica considered as ruby appears, however, to reflect a greenish tint, it falls victim to the personal equation, which is always present in qualitative sorting and appraisement of mica. In many instances it must be sold as Madras first-quality or second-quality green, as the case may be. The colour of ruby mica varies from mine to mine, and the uncertainty in regard to its being ruby or green seems to be irremovable as long as the qualitative classification of mica depends on visual tests. The only exception to this rule is the product of the Kalachedu mine, which is the oldest and one of the largest mica mines in the world.



MADRAS MICA AREA

Scale of Miles

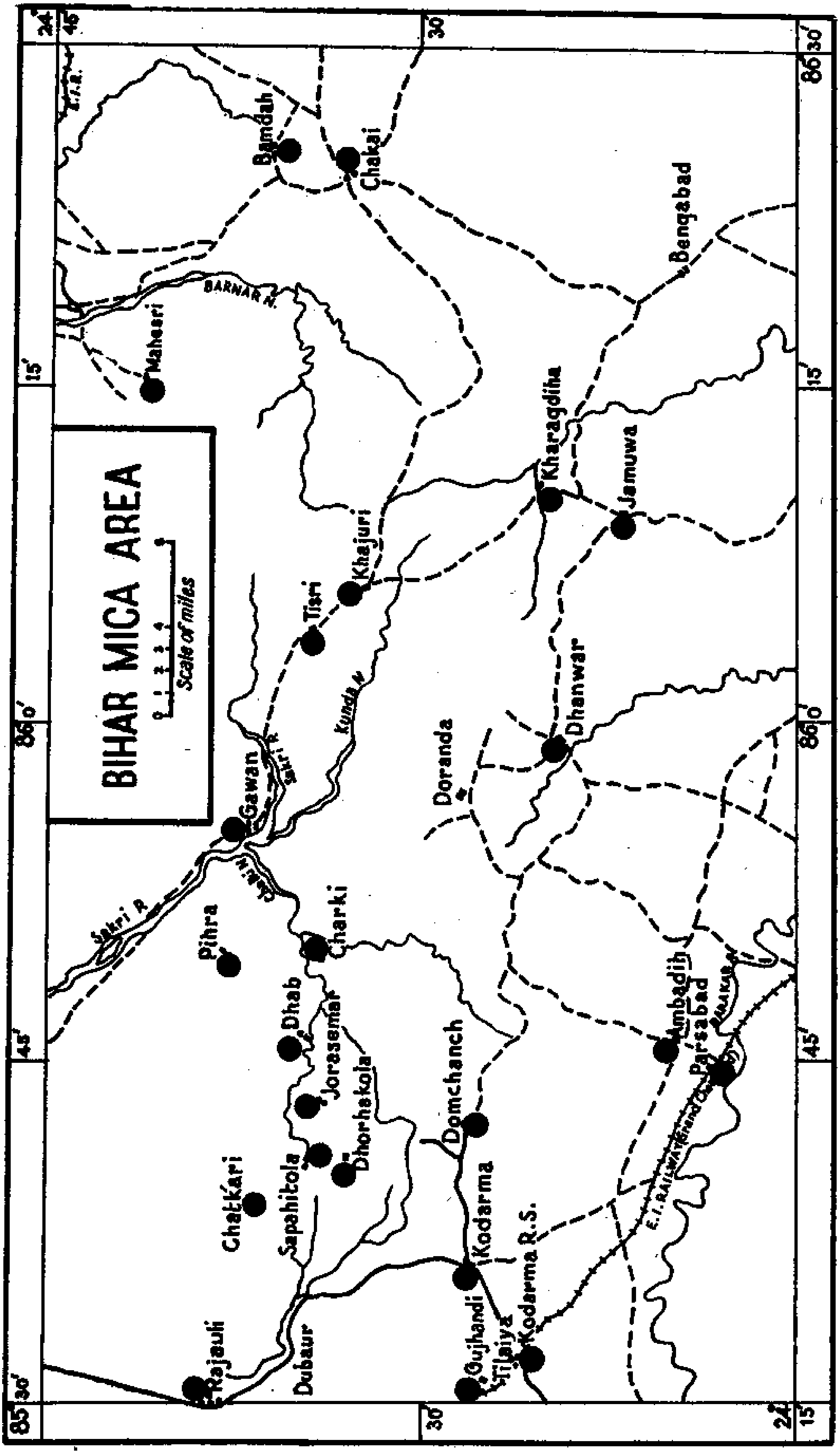
Practically the entire production of Madras mica is shipped to foreign countries from the port of Madras, and the grading and classification of Madras mica differ considerably from those of Bihar.

The age of the Bihar mica industry in its modern form is approximately seventy years. In the early days, mica mining in Bihar was dependent solely on manual labour. But with the gradual increase in the depths of mines, equipment such as boilers and pumps were introduced. These have been supplemented in recent years by small compressed-air units and hoisting machines.

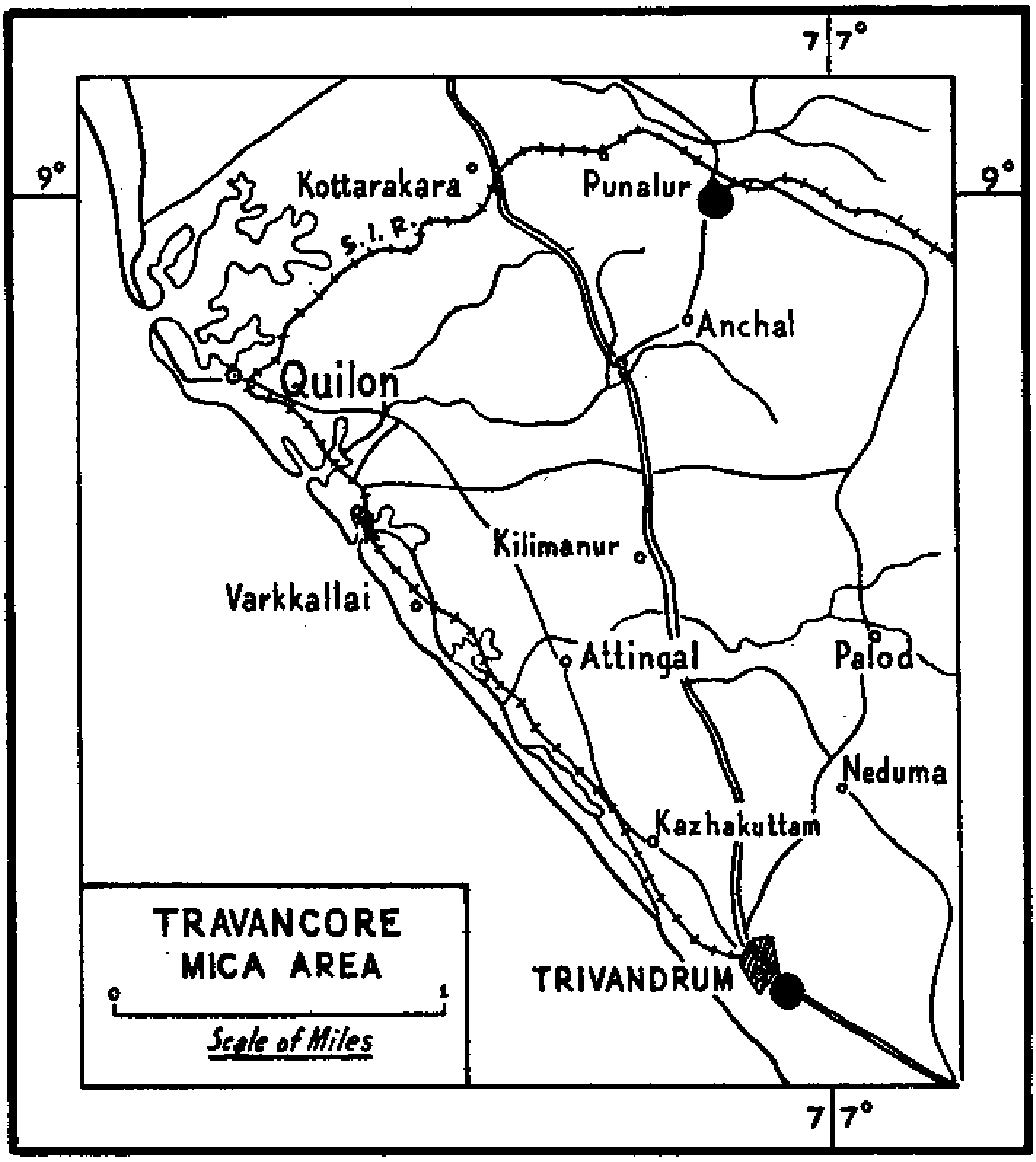
The mica mines of Bihar are located mostly in deep forest areas, and in the olden days the extremely bad roads made the problem of transportation very difficult. Even a couple of decades ago, the use of trucks for transporting mica from the mines was thought to be impossible. The number of cars in the entire mica field was negligible in comparison with today. In early days bullocks and bullock carts and horseback were the only means of transportation, and at times it took a mine owner more than a week to reach the mines from the manufacturing centers. Extensive road improvements and the availability of suitable cars and trucks have improved the transport facilities to a considerable extent. Today we find practically every mine operator owning a car or truck. Moreover, steam and compressed-air power have improved mining practice considerably. Unfortunately, though, no improvement whatsoever has yet been effected in the prospecting of this valuable mineral, which still depends on the good old trial-and-error method.

Since the very inception of this industry in Bihar, many difficulties and handicaps have been experienced by the interests concerned; and it is, indeed, a pity that, though Bihar mica holds a unique position in the list of the world's strategic materials, this industry is still generally unknown to the industrialists of India. Little or no effort has yet been made to establish industries that will provide a home market for Indian mica. Though about three-quarters of a century have passed since mica was first mined on a commercial scale, problems of the mica industry have still to be considered in terms of conditions over which we have no adequate control. In spite of there being considerable foreign interest in this industry from the beginning, practically no effort has yet been made to organize a research institute in this country to examine the various complex problems relating to mica.

The most difficult problem at the moment is the finding of eco-


BIHAR MICA AREA
0 1 2 3 4 5
Scale of miles
24°
45'
30'
15'
85°30'
86°0'
86°30'
45'
15'
Bamdah
Chakai
E.I.R.
Bengabad
BARNAR N.
Mahesri
Kharagdiha
Jamuwa
Khajuri
Tisri
Dhanwar
Doranda
Sakri R.
Kundu N.
Gawan
Pihra
Charki
Dhab
Jorasemar
Dhorhakola
Saphitola
Chatkari
Domchanch
Kodarma
Kodarma R.S.
Gujhandi
Tilaiya
Rajauli
Dubaur
Ambadih
Parsabad
E.I. RAILWAY (Grand Chord)
BARAKAR R.

nomically workable mica deposits, which since the very beginning of mica mining have been dependent on crude methods. It is very disappointing to note that no satisfactory scientific method of prospecting for mica has yet been developed. Although there has been tremendous progress in every other sphere of the industrial world, mica mining continues to retain its unusually speculative character.



During the last two years of World War II a substantial amount of propaganda was published, regarding a number of problems confronting the industry, by certain vested interests in various newspapers and monthly and weekly journals of India. It is a great pity that efforts have been made to give undue prominence to problems that are either imaginary or exaggerated, while the public is kept in the dark about the real problems. The only problems that have been discussed with controversial zeal are mica piracy and conservation of mica. I make no apology for calling these difficulties imaginary or exaggerated, for I shall discuss them in detail in the following pages and the impartial reader will, I am sure, agree with me that the problems are largely unreal.

The prolonged and bitter controversies over mica piracy and conservation of mica attracted the attention of the Government of India. Consequently an enquiry committee was set up, known as the Central Mica Enquiry Committee, with a high court judge as its chairman and two industrialists outside the mica trade as members. This was the first of its kind in the history of India.

The following is the full roster of the Central Mica Enquiry Committee:

MR. JUSTICE D. E. RUEBEN, High Court Judge, Patna
Chairman

LALA GURU SARAN LAL of Gaya
MR. MD. ISMAIL SAHEB, Madras
Members

MR. CHANDMULL RAJGARHIA, Giridih
MR. E. WATSON, Domchanch
MR. D. NARAYANA REDDY, Gudur
MR. RAMKUMAR AGARAWALA, Bhilwara-Rajputana
As assessors from the trade

MR. P. S. PRASAD, Kodarma
MR. S. Y. KRISHNASWAMY, Madras
As assessors from government

MR. C. BHATTACHERJEE, Giridih
As assessor representing labour

The Director, Geological Survey of India

and

The Director, Board of Scientific and Industrial Research
As technical experts

It was encouraging that, through this committee, for the first time in the history of Indian mica development, the Government of India at last gave some attention to this neglected industry. The terms of reference of the Central Mica Enquiry Committee were as follows:

1. Immediate problems relating to the Mica Control Order, 1940, both in regard to war production and to the effect of the order on long-term policy, and the review of any order that may have been passed by the government in connection with that order.

2. Present system of marketing, both in India and abroad.

3. Standardization of quality.

4. The extent to which alternative sources of supply may have jeopardized or are likely to jeopardize the position of this country as principal supplier of muscovite mica and the extent to which other materials that may be used as substitutes for mica may have been displaced or are likely to displace mica from its uses in the industry.

5. Increased utilization of mica in this country for the manufacture of finished goods.

6. Research, conservation, and development.

7. The desirability of setting up a suitable machinery, whether by appointment, through a central mica committee, or otherwise, to watch the interests of the mica trade and industry.

8. Any other matter of importance that may be brought to the attention of the committee.

The above terms of reference, it would seem, included all the vital problems of the industry besides the spurious controversial ones referred to already. If some reasonable solution could be found by the Enquiry Committee for the real problems, the industry would have a splendid opportunity to gain an important position among the other leading mining industries of the world.

The Bihar mica industry consists of two classes of people, mica miners and mica dealers. Among the miners, those who are shippers manufacture or prepare their entire production and ship it to foreign countries, and the remainder sell it directly to shippers or so-called "manufacturers." There are also local dealers who sell it to the shippers or manufacturers.

The mica dealers may be generally grouped into three classes.

1. Dealers who buy mica from the local market and manufacture it to required specifications and ship it directly to foreign countries or sell it to shippers.

2. Dealers who deal in crude and bima mica (mixture of two or more grades of S.D.B.) and also in graded S.D.B.

3. Dealers who manufacture and deal in splittings only.

This is a rough classification of dealers. There are cases, of course, where a single dealer has all the three different functions. Usually manufacturing of mica, except splitting, is confined to a limited number of dealers and miners. The qualitative sorting of block or sheet mica and the manufacture of condenser films and book-packed splittings is done mostly by shippers, while quite a number of both miners and dealers are engaged in the manufacture of specially smaller grades of loose splittings (mostly No. 6).

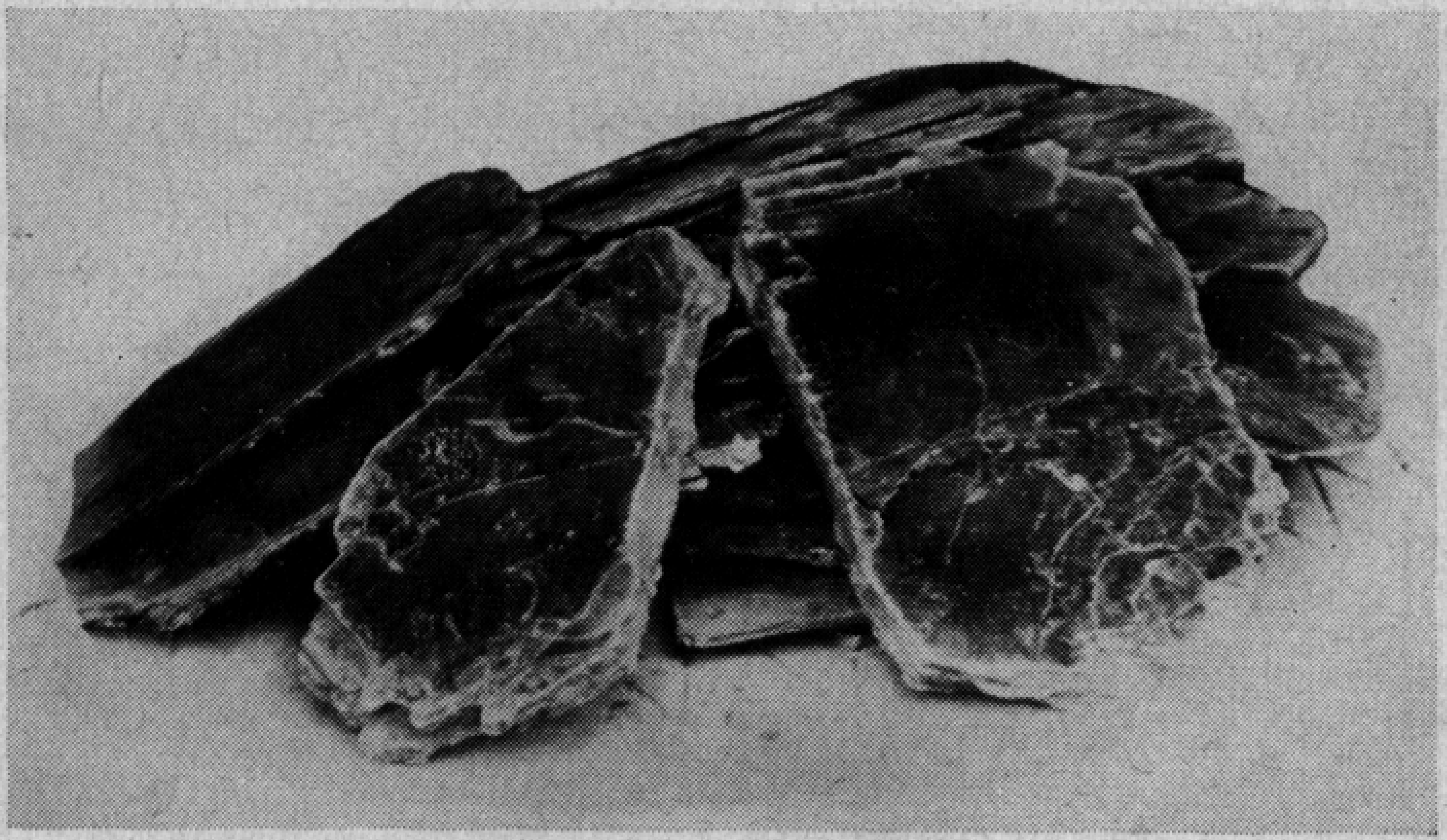


FIG. 1. Crude mica, locally known as *kachha mal*.

Mica is found associated with a type of rock known as "pegmatite." Unlike most other minerals, mica is separated from its associated rocks solely by hand picking after the rock has been broken. The mica thus recovered is termed "crude mica" and is locally known as *kachha mal* (Fig. 1). After mica has been mined, it is split to a thickness between 8 and 30 mils (1 mil being 0.001 in.); the thickness of these split pieces is kept on the higher side and the production of pieces thinner than 8 mils is avoided as far as practicable. Then the sides of split pieces are dressed with sickles. When mica has undergone this preliminary process, the bulk is termed "sickle dressed block," known as S.D.B. in abbreviated form or *hasua katai mal* in local terms (Fig. 2).

The bulk of S.D.B. is first sorted according to various sizes, and before it undergoes this grading the mixed bulk is known as "bima."

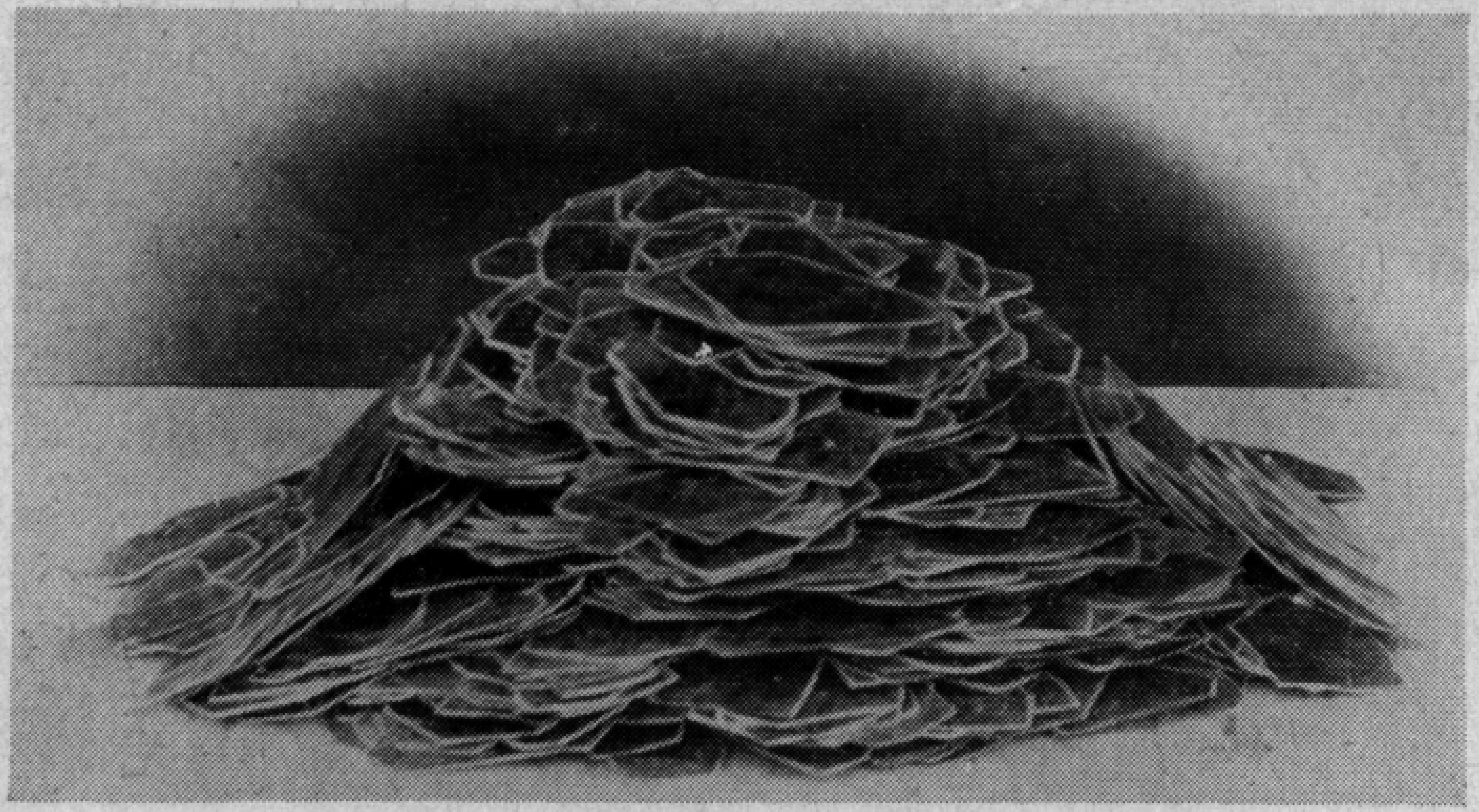


FIG. 2. Sickle dressed block (S.D.B.) is locally termed *hasua katai mal*. Block mica (about 8 to 30 mils) is locally known as *Tikri*.

Commercially mica can be roughly grouped into three classes according to thickness:

1. Block mica (8 mils to 30 mils), locally known as *Tikri* (Fig. 2).
2. Chillas or cleanings (below 8 mils and above 1 mil) locally known as "chillas" (Fig. 3).
3. Splittings (below 1¼ mil), locally known as *phakni* (Fig. 4).

Besides these, there is another class, which has become quite common in recent years: films or condenser films. The difference between this particular variety and the mica splittings is that these films are manufactured from better quality blocks (usually good stained and up) in specified thickness, generally ranging from 0.001 to 0.004 in. Splittings, on the other hand, are manufactured from the lower quality blocks, or chillas, which cannot be sold as block mica or thin blocks or used for the manufacture of condenser films.

In the early days of the mica industry, the province of Bihar was

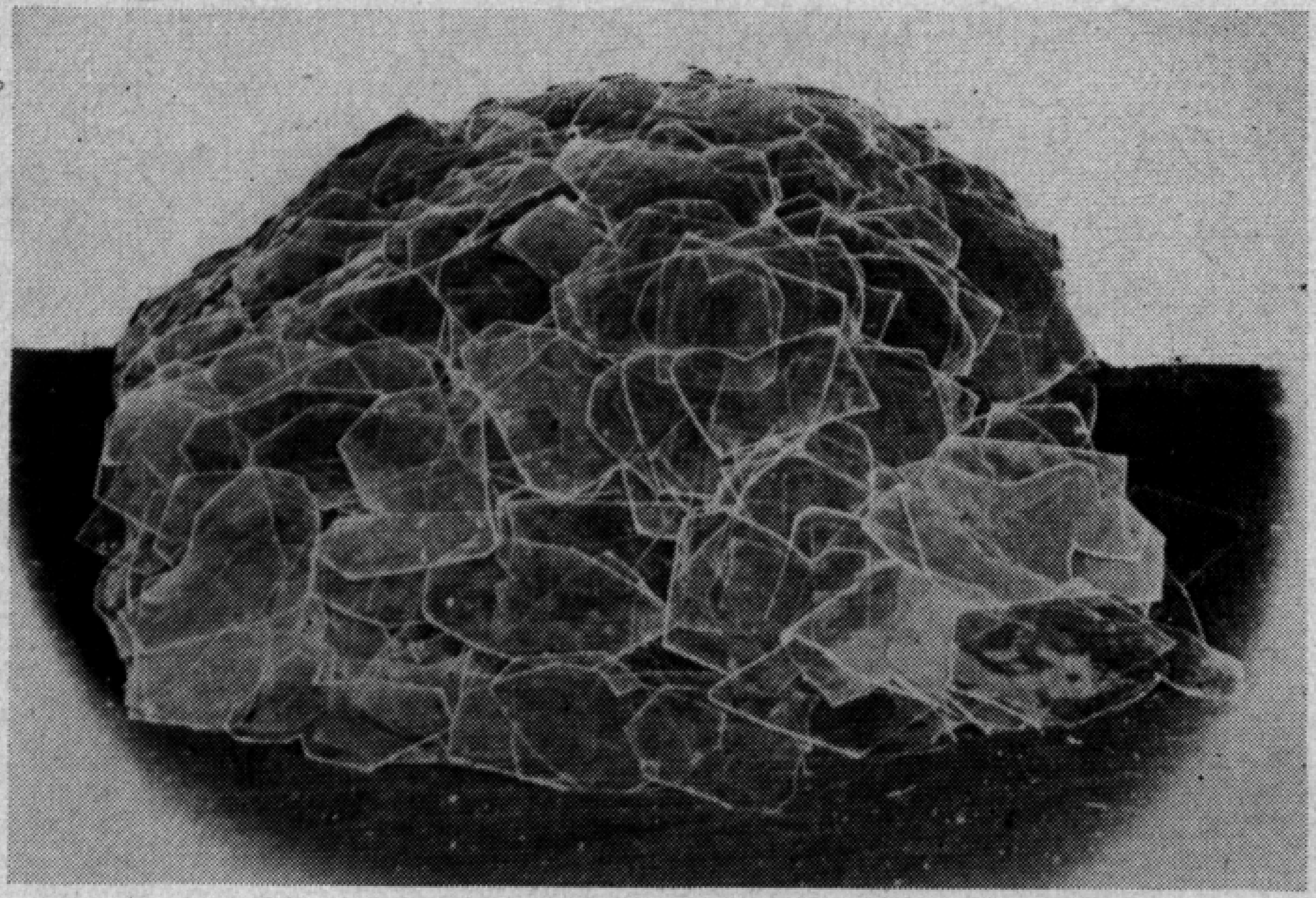


Fig. 3. Cleanings below 8 mils and above 1 mil are locally known as "chillas."

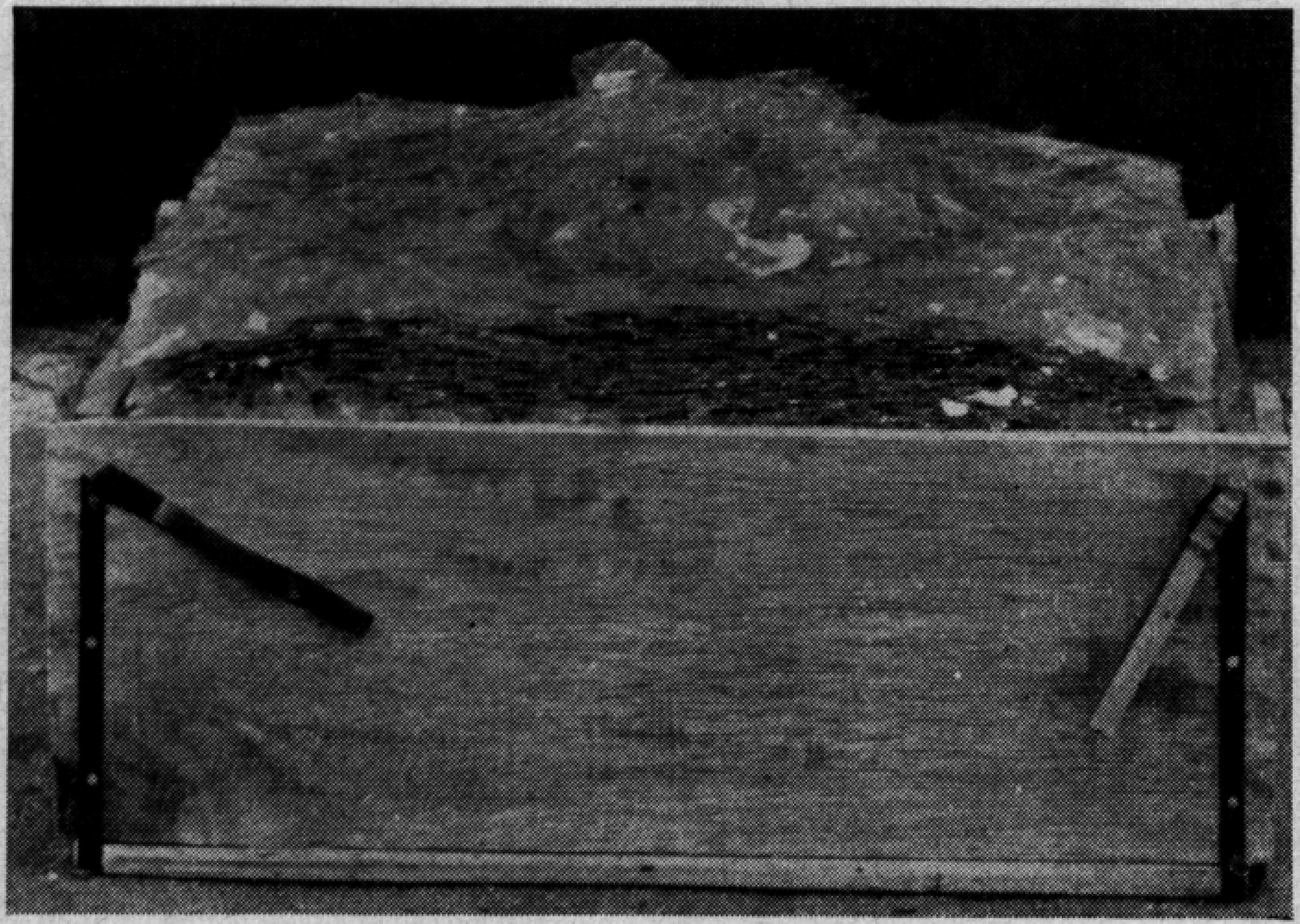


Fig. 4. Splittings below 1 mil are known as *phakni*.

a part of the province of Bengal and as such Bihar mica is still known in foreign countries as "Bengal mica." In Madras even today people call the S.D.B. "Bengal-cut mica." But since the separation of Bihar from Bengal in 1911 and its formation as a separate province, no mica-bearing land falls within the areas covered by the province of Bengal. Hence the term "Bengal mica" is a misnomer and its use an anachronism.

The Bihar mica deposits are spread over an area of 1,500 sq. miles and are worked by hundreds of concerns, while more than 60 per cent of the total production of Bihar is contributed by only a dozen concerns. The Bihar mica industry provides employment for about 250,000 labourers. The most redeeming feature of this industry is that it affords accommodation to all classes of people in terms of their financial standing. Practically the entire production of Bihar is exported to foreign countries from the port of Calcutta. Though the total production of Bihar mica fields represents roughly 25 per cent block or sheet mica and 75 per cent mica splittings, the export is entirely dependent on the law of supply and demand and so does not conform to the above proportion. Though Bihar was always in the world's mica market, its commanding position was firmly established only with the evolution of built-up mica, or micanite. This established the demand for thin splittings of moderate size, which Bihar was in an advantageous position to produce in large quantities because of the abundance of suitable mica and labour.

Notwithstanding all its natural advantages, the seventy-year-old mica industry of Bihar still labours under all the liabilities of its infant stage. It can hardly be regarded as a robust growth or a well-established industry that can stand comparison with other mining industries in the country. While such an unsatisfactory state of affairs can be explained to some extent by the foibles and failings of those who are engaged in the industry and the trade, it must be attributed chiefly to the complete absence of a home market and the consequent dependence on foreign markets for the consumption of its whole output. With such complete dependence on foreign buyers, there is little or no bargaining power and the industry has suffered continually because of low prices received for its products.

CHAPTER 2

Some Geological Considerations of Pegmatites

Common mica (muscovite) is found in workable quantities in a rock known to geologists as "pegmatite." These pegmatites are granite-like masses containing quartz and feldspar (both potash and soda feldspar) and mica (both muscovite and biotite). Besides these principal constituents, all of which may vary in size and amount, the pegmatite may contain other minerals, such as garnet, tourmaline, apatite, and beryl. Indian pegmatites also include eschynite, allanite, cassiterite, columbite, tantalite, gadolinite, monazite, pitchblende, samarskite, sipylite, and other uncommon minerals.

Indeed, these pegmatites of India might be called "nature's field museum of mineralogy." Generally, the quantities of minerals other than essential minerals are so small that, except in few instances, where they are by-products, they have no commercial value.

The pegmatites are lenticular in shape. Their most common characteristic is the concentration of mica in a wide range of variations. The percentage of those veins which are considered rich enough to be developed into large mines is small—not even 2 per cent, to be precise. Of the total quantity of mica mined from such veins, the maximum percentage of marketable mica is not over 20 per cent. There are many pegmatites in the field that are barren of commercial mica.

There are a number of theories regarding the origin or mode of formation of these pegmatites, and, the subject being a very debatable one, nothing definite can be said.

Some geologists are of the opinion that these mica-bearing pegmatites are the crystallized products of the residual portions of the slowly cooled molten granitic magma, which have entered the cracks and fissures of the ancient Archaean country rocks, known generally as "gneisses" and "schists." According to some petrologists, the crystallization of the simple pegmatitic magma was followed by the replacement of previously formed minerals and deposition of new and rarer minerals by hydrothermal solutions derived from the same magma. Some geologists believe that the pegmatites are the crystallized products deposited from superheated waters that contained mineral matter in solution and were carried into schistose country rock. This heated water is believed to have been derived from adjacent magmatic intrusions of granite. Recognized authorities consider that the pegmatites sometimes are due to recrystallization of material that had been under great pressure. It is, however, generally admitted that these pegmatites are intrusions of one kind or another of younger, well-crystallized materials in older rocks. Some geologists describe them as "dykes" and some call them "projections of dykes."

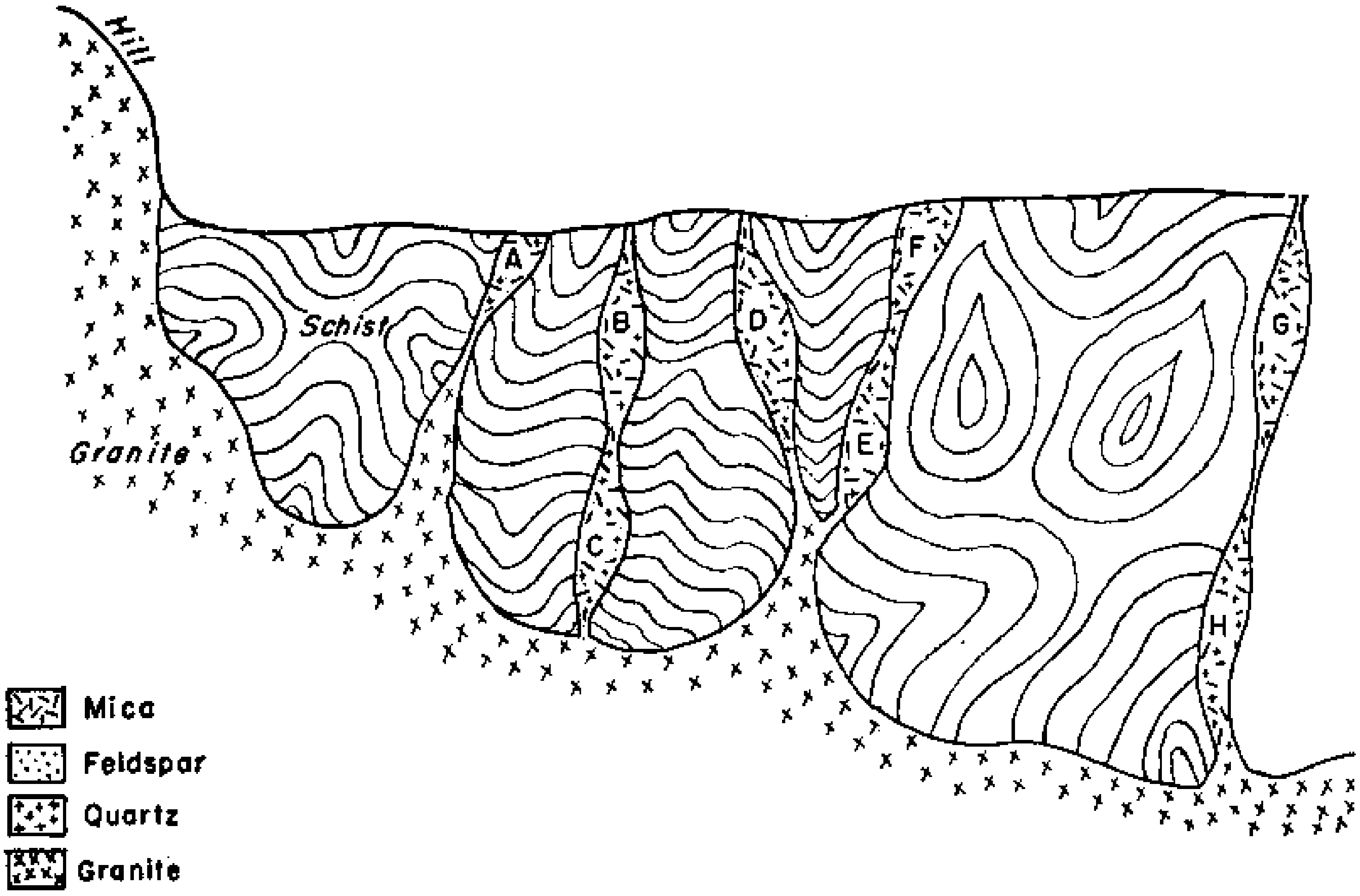


FIG. 5. Diagrammatic sketch showing schist containing pegmatite lenses *A, B, C, D, E, F, G,* and *H,* in which mica occurs.

Figure 5 is a diagrammatic sketch explaining how mica pegmatites or veins may occur in schists.

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Generally speaking, there are four types of pegmatites or veins in the Bihar mica fields.

1. Lenticular veins.
2. Massive veins.
3. Pipe veins.
4. Banded veins.

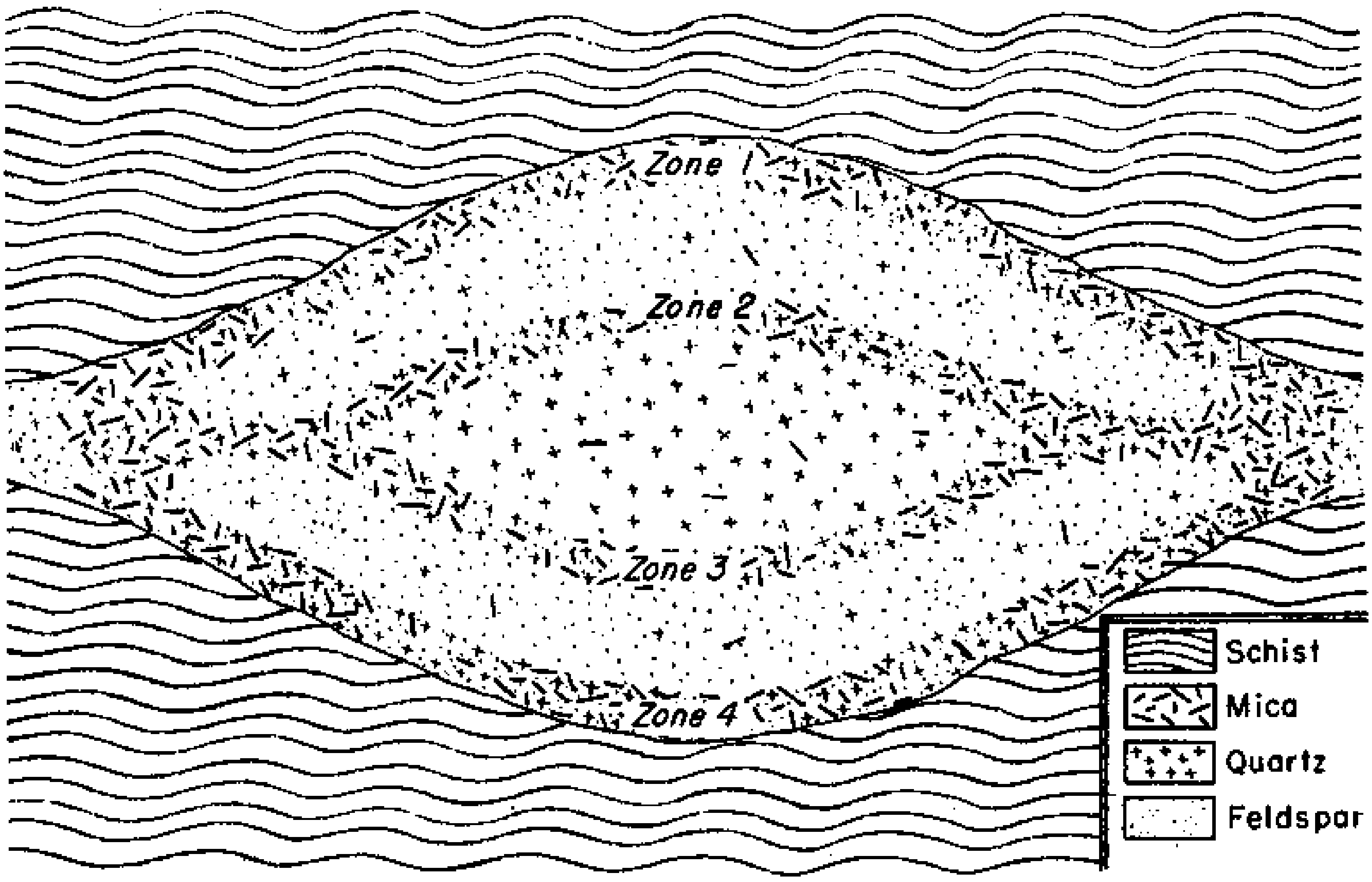

FIG. 6. A (hypothetical) horizontal projection of a lenticular mica vein with four zones of possible mica concentration.

These four types could be expressed as being only lenticular, thinning out vertically and horizontally, but this classification is based on their different behaviours.

Lenticular Veins. It has been found that in lenticular veins concentration of mica is restricted to four zones, which are as follows:

1. Junction of hanging-wall schist (the country rock) and feldspar.
2. Junction of quartz and feldspar closer to the hanging-wall schist.
3. Junction of quartz and feldspar closer to the footwall schist.
4. Junction of footwall schist and feldspar.

Figure 6 is a sketch representing a lenticular vein.

The foregoing description does not necessarily mean that the four zones generally have workable concentration of mica. Usually one zone is found to be productive and in some cases two zones are fairly well concentrated. Experience has shown that the lenticular veins are the most dependable and productive.

In many cases when the width of the pegmatite between the hanging-wall and the footwall schists is within 10 to 15 ft., zones 2 and 3 in Fig. 6 are found missing altogether and the concentration of mica is found between the quartz core and the footwall schist and/or the hanging-wall schist, as shown in Fig. 7.

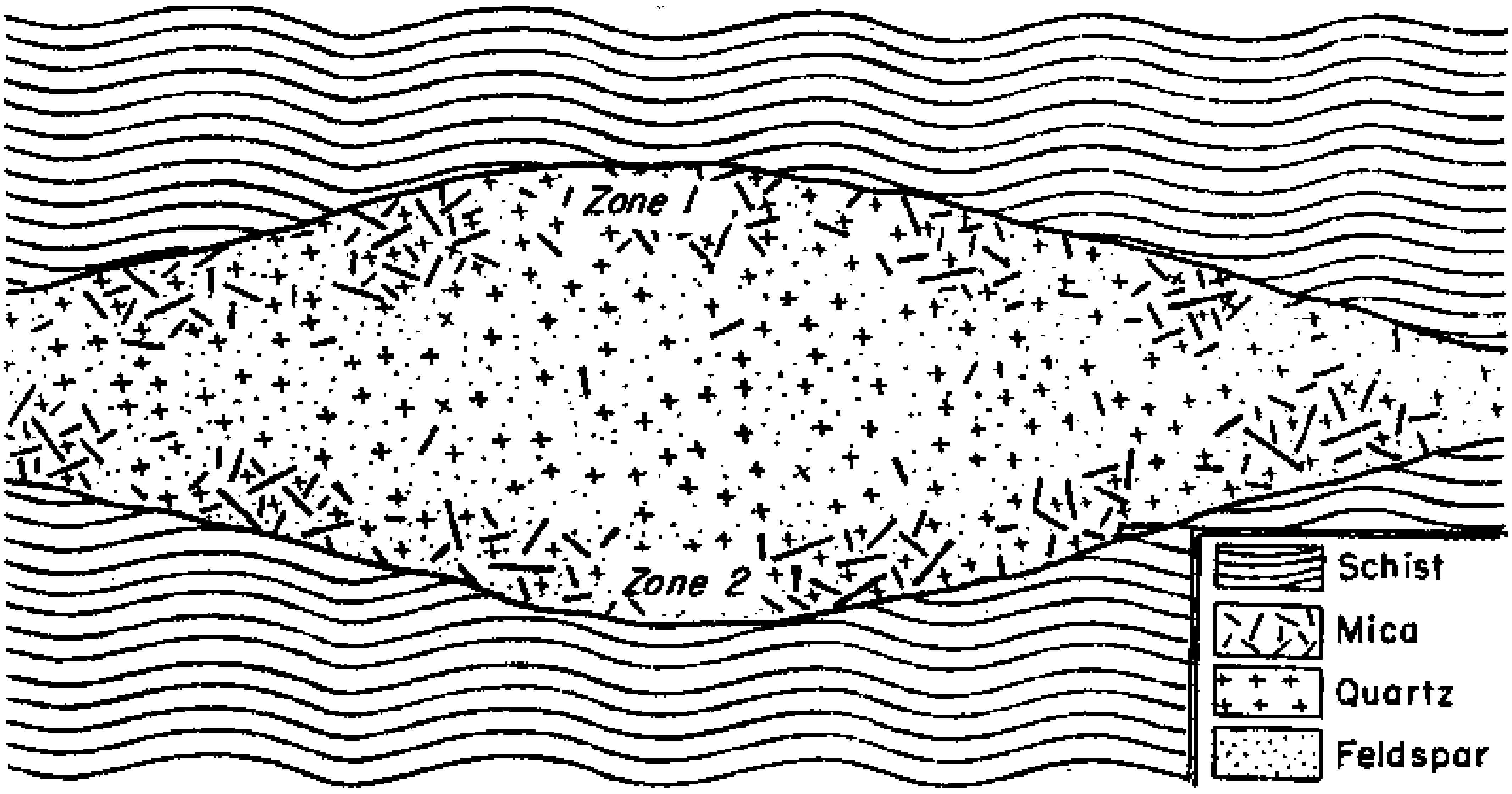

FIG. 7. A (hypothetical) horizontal section of a narrow lenticular vein with only two zones of concentration.

To give a true picture there is one peculiar feature worth mentioning about the concentration of mica in the productive zone of these pegmatites.

This is shown in Fig. 8, which is a longitudinal section along the productive zone of a pegmatite. In most cases, the concentration of mica is not fully uniform or regular throughout the length and breadth of a pegmatite. The existence of fairly large barren patches, mostly of feldspar, is so common that, apart from the pinching out of the vein, sudden disappearances of mica from the working faces along the dip and strike is a sort of everyday affair, and one is often faced with dead work which may vary 5 to 25 ft. or even more.

The author developed one mine that extended 1,800 ft. along the strike. In the course of development, more than a score of times such barren zones were encountered. This mine failed at a depth of about 150 ft. In another mine, development has already been done to the extent of 1,000 ft. along the dip, and in this case also a number of barren zones were encountered. The average length of the strike is about 400 ft. in this mine. These are, however, exceptional cases of unusually extensive pegmatites rich in mica.

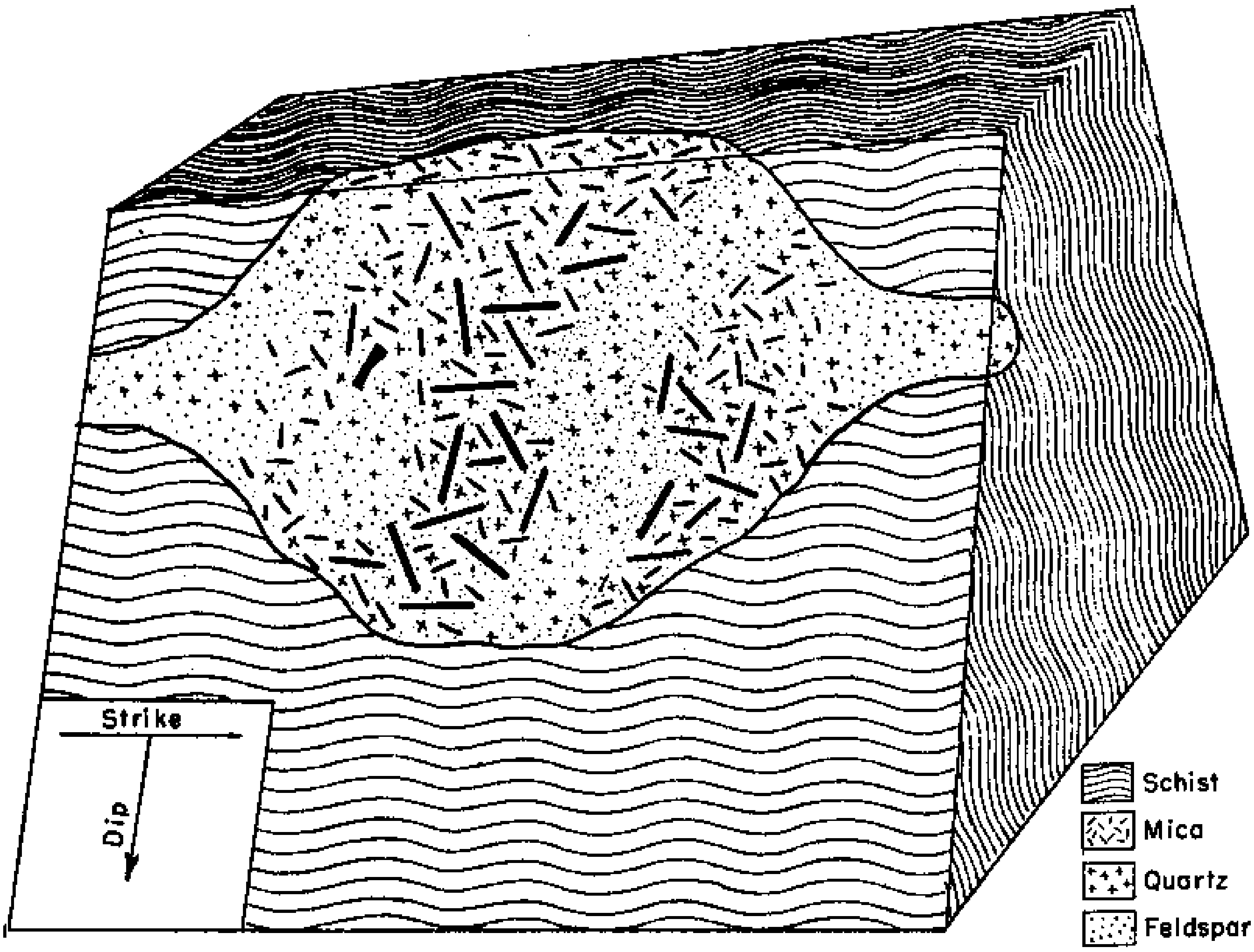

FIG. 8. A (hypothetical) pictorial view on which is shown a longitudinal section along the productive zone of a pegmatite. The sketch also explains the dip and strike.

Generally these veins, popularly considered rich, extend to a depth of 300 to 400 ft. along the dip and about the same distance along the strike and then thin out in both directions. But in some cases, there is a very substantial probability of these veins widening out again both vertically and horizontally after a distance of anything between 5 and 50 ft. or more. It is here that operating a mica mine calls for some amount of patience, a speculative spirit, and breadth of outlook. Figure 9 explains clearly this behaviour of pegmatites. Between the lens *A* and *B* in the sketch, the portion *X* has thinned out and is a narrow zone containing no workable quantity of mica. To reach lens *B*, this zone must be crossed, and it is here that the science of geology is disappointing, because it does not present any definite evidence of the existence of lens *B* or the concentration of mica in it. Nor does it indicate anything about the extent of this narrow zone. The only course left to the mine operator under these conditions is to take his chance and sink through this narrow zone for a reasonable distance to ascertain the existence and the nature of the lens *B*.

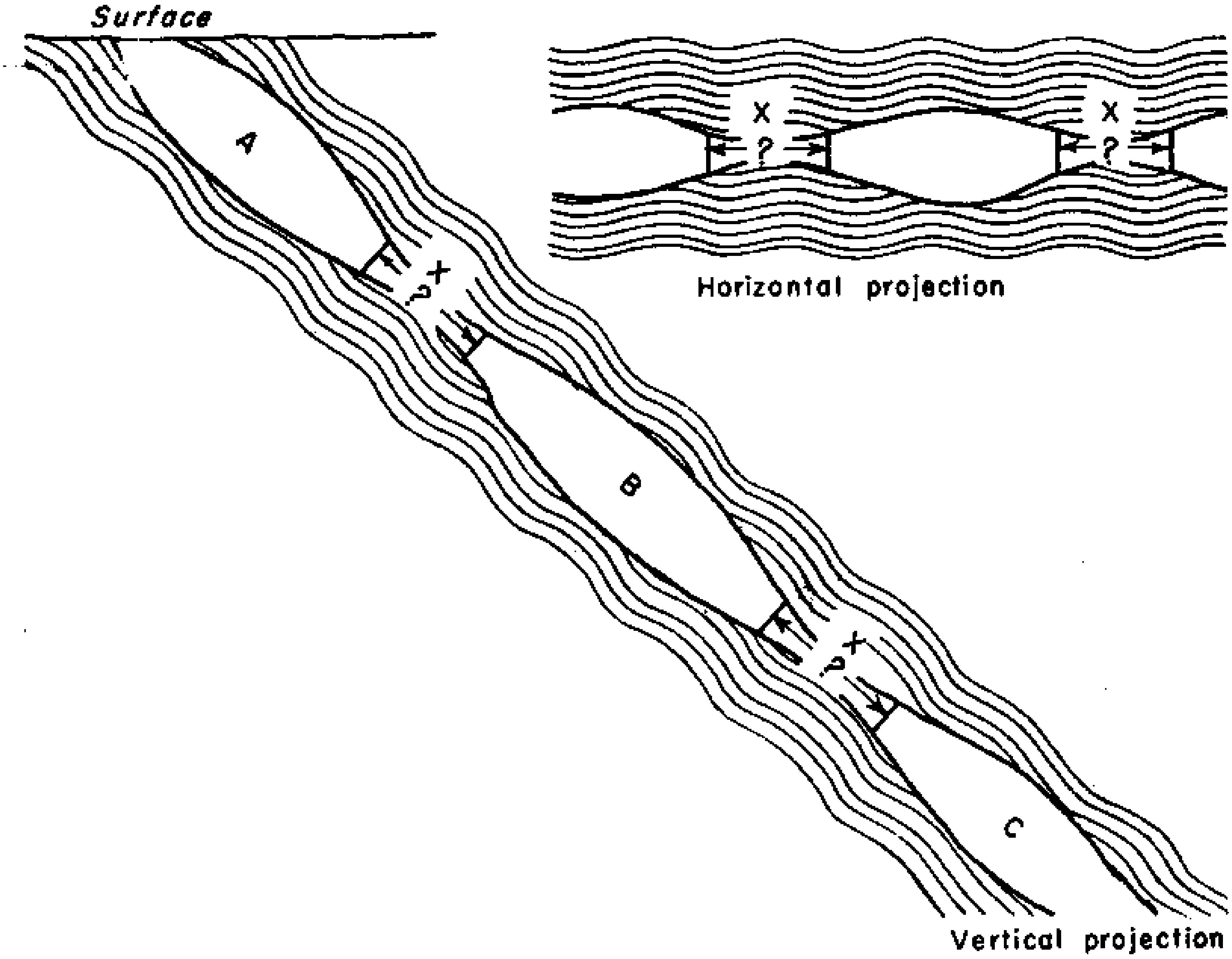

Fig. 9. A horizontal and vertical projection showing the behaviour of pegmatites, thinning and widening at intervals, and explaining how an unfortunate lack of any scientific assistance to determine the extent of a thinned-out zone or the presence of a workable quantity of mica in the second lens sometimes discourages prospecting.

It is difficult to say what may be the reasonable extent of such dead work referred to above. It should depend on the nature and behaviour of a particular deposit. For example, if in the lens *A* in Fig. 9 the concentration of mica had been quite rich and regular, predominating in larger grades of sound mica, both in the direction of dip and strike, sinking should extend at least 50 ft. through the barren rock. In exceptional cases, sinking to a depth of 100 ft. could be justifiably recommended. But in the absence of scientific assistance in this matter, nothing but limitations imposed by economic considerations can possibly determine the extent of dead work that could be called "reasonable." It is a matter of experience that one who has earned a fortune from the first lens can never desert the deposit before thoroughly satisfying himself about the absence of a second lens. In case his efforts are crowned with success, the fortune that he may earn is multiplied two, three, or even four times. It has often been observed that the concentration and size of mica in a second lens, if productive, are comparatively greater than those of the first lens.

Though success cannot be guaranteed, taking a chance on final testing is worth while; otherwise the belief that one has lost a good prospect for the lack of speculative spirit is kept perpetually alive.

For a concrete case, the example of the Tharghati mine located in the Dhab mica area, owned by the Indian Mica Supply Co., Ltd., and worked exclusively under the author's direction, could be mentioned. In 1935, a shaft was sunk to enter this mine, which had been abandoned by predecessors as a result of the vein thinning out at a vertical depth of about 100 ft. and an inclined depth of about 200 ft. along the dip. The vein was lenticular and the average thickness of the pegmatite was about 25 ft. The only productive zone was at the junction of hanging wall and feldspar. The thickness of the rich productive zone was about 4 ft. and it had pinched out to about 5 in. The mine was then abandoned. There were some barren pillars left to protect the roof, and since the hanging-wall schist was very hard and massive there was no subsidence. The mine was entered through the new shaft, which was about 90 ft. deep, and started following the thin stringer along the dip. Development continued along the stringer for about 30 ft., when it started to widen, giving us hope to continue. At 40 ft. the concentrated zone widened to about 5 ft. and contained exceptional concentrations of mica.

In another case the results were disappointing. In 1944 I purchased a mine in the Government Reserve Forest. This mine is famous in the Kodarma area and is known as the Harinchurwa mine. The previous owner had worked the mine to a vertical depth of about 160 ft. The average thickness of the vein was about 35 ft. and pinched out to 2 ft. in the deepest section, then turned completely barren. In this particular mine, both hanging-wall and footwall sections were productive and the bulk of the mica output predominated in larger grades. The quality of mica was also very good. All these bright points tempted me to speculate a bit and I followed the vein along the dip. After advancing 10 ft., the vein widened out, and at 20 ft. the vein's thickness increased to such an extent as to make it impossible to expose both the hanging-wall and footwall schist. The hanging-wall schist was followed to a depth of 60 ft., with no concentration of mica found. In expectation of a concentration toward the footwall side, a crosscut was driven from the upper section. After the crosscut had continued for about 25 ft. through barren pegmatite, the footwall schist was exposed, and there the expected zone of concentration was found absolutely barren, except for a very narrow stringer about 2 in. wide with a few bits of mica in it.

The whole venture was at this point considered a complete failure, but the manager of the mine blasted a few holes following the stringer as a last desperate effort and some amazing results were obtained. The stringer widened to 6 in. and the first blasting gave a production of about a maund (82.5 lb.) of crude mica, with an unusual predominance of medium-size and thick sound books. The stringer was developed further; but after a 5-ft. advance, though the width increased 1 ft., concentration of mica became less and a layer of schist pinched the vein again after 10 ft.

On the assumption that this particular point was the beginning of a productive zone, development continued along the dip. As fate would have it, the stringer disappeared, and the entire venture had to be given up as a bad gamble.

Judging from both cases—one a glorious success and the other a miserable failure—it must be concluded that to give up a mine without doing this bit of final testing is unwise and is a serious offense against the conservation of mica.

It should be mentioned here that some of the big mine operators are worse offenders in this practice than the smaller ones. The harm done by a small operator is more easily rectified than that of a large operator.

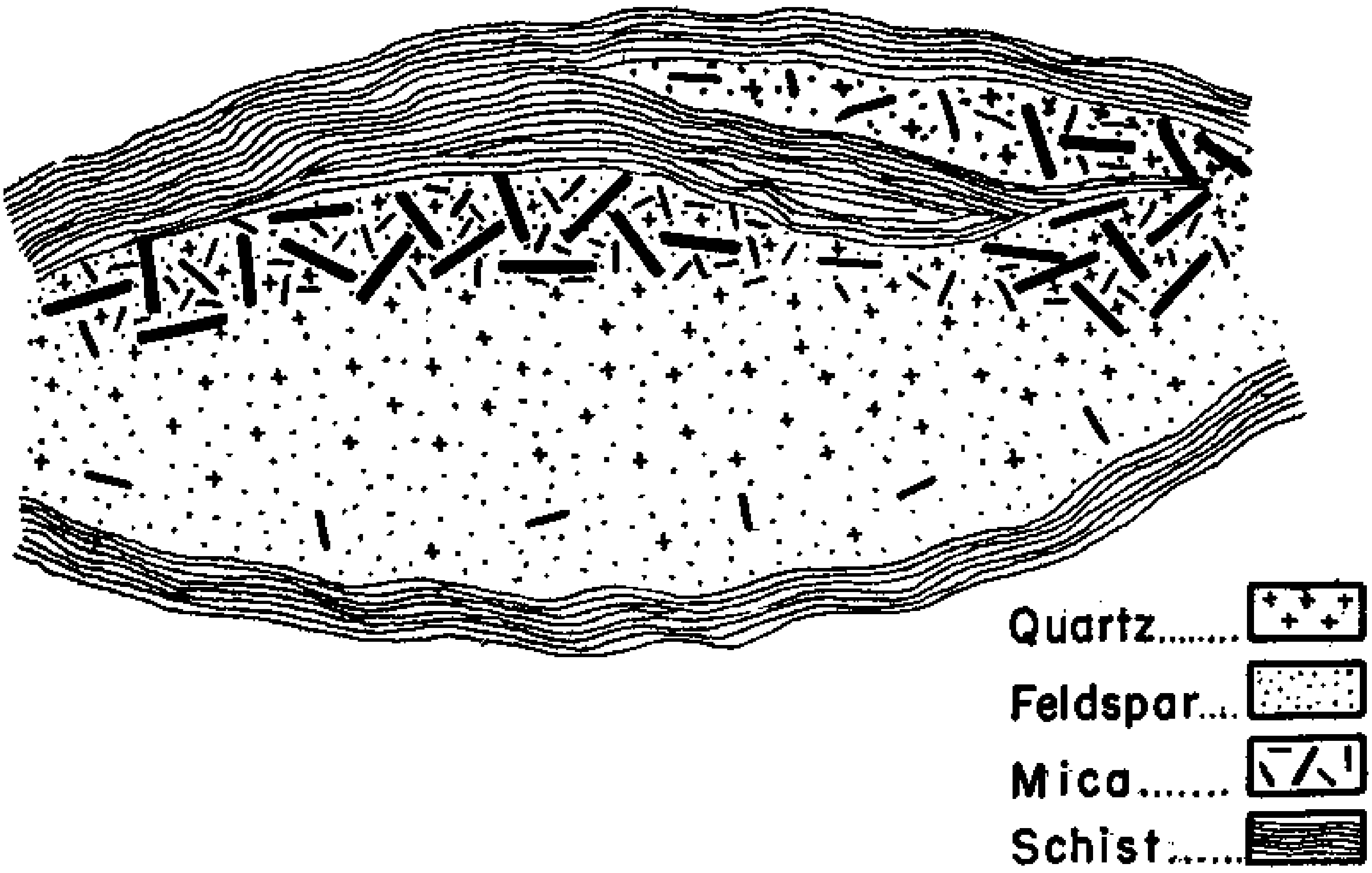

FIG. 9*A*. Sometimes a layer of schist suddenly appears in the productive zone of a mica pegmatite, bifurcating the vein, and robs the mica concentration.

The sudden appearance of a layer of schist in a productive face is more or less a common feature of these lenticular veins and they are a headache to the mine operator. Generally it appears as a thin layer of about 6 to 9 in. bifurcating or forking in the productive zone. But with the advance of the working face as the width of this layer increases, the concentration of mica gets poorer and poorer, and ultimately the production from such a face declines 90 to 95 per cent. If the advance continues and such a layer starts getting thinner, the concentration of mica improves and, ultimately, when it disappears, the face assumes the original character once again (Fig. 9*A*). In exceptional cases, however, except for bifurcating the productive zone, it does not appreciably affect the concentration of mica in the vein. But, in such cases, it becomes very deceptive and hides a section of the productive zone from the mine operator, who often mistakes it for the hanging-wall or the footwall schist. The Sibsankar mine, situated in the village of Sankh of the Doranda mica area, owned and worked by the author, is a typical example.

This vein, though lenticular in all respects, has no prominent central quartz core and throughout the vein between the hanging-wall and footwall schists, there is more or less concentration of mica. This vein has been developed in the usual way to a depth of 200 ft. with seven levels. In level 5 the width of the productive zone varied from 5 to 8 ft. This level gave substantial production for about 150 ft. along the strike. Levels 6 and 7, as well as the winze from level 7, which is about 32 ft. deep, contained less concentration of mica than level 5, although the width of the pegmatite at these places remains the same as in level 5. While development was under way in the deepest sections of the mine, production declined sharply.

Primarily with the view to increase production, instructions were issued to put a raise from the roof of level 4 at the point marked *Z* (Fig. 9*B*). At that time no one had the faintest idea about the existence of a rich vein concealed by a thin layer of schist along the hanging-wall side. While making preparations for putting the raise a few bits of mica sticking to the hanging-wall schist attracted the attention of the shift boss. To satisfy his curiosity and also to extract these small books of mica, four holes were drilled into the hanging-wall and blasted. The results of this blasting were rather amazing. About 300 lb. of crude mica was obtained and it was revealed that the schist which had been believed to be the genuine hanging-wall was only a layer 9 in. thick and behind it was a rich vein of mica. Crosscutting at this face was started with full force and after an advance of about 8 ft. another schist was met. This crosscut yielded substantial production and the mica was sounder in character than that obtained from the section originally worked. A drive was then started along the strike in both the east and west directions. After 8 ft. of advance the vein in the east drive became very poor and pinched to about 1 ft. The west drive yielded substantial production for about 30 ft. and then joined to the section originally worked. The layer schist vanished but the vein pinched to about 1½ ft.

A winze was started from the point *X* (Fig. 9*B*) and after 35 ft. of sinking, a crosscut was driven through the footwall layer for making a connection with the original level 5. After 2 ft. of crosscutting a new zone of concentration was encountered. It was 4 ft. wide with comparatively poor but workable concentration of mica. After further crosscutting for about 2 ft. through schist the desired connection with the originally worked section was made. Figure 9*C* is a vertical cross section of the portion of the vein between levels 4 and 5.

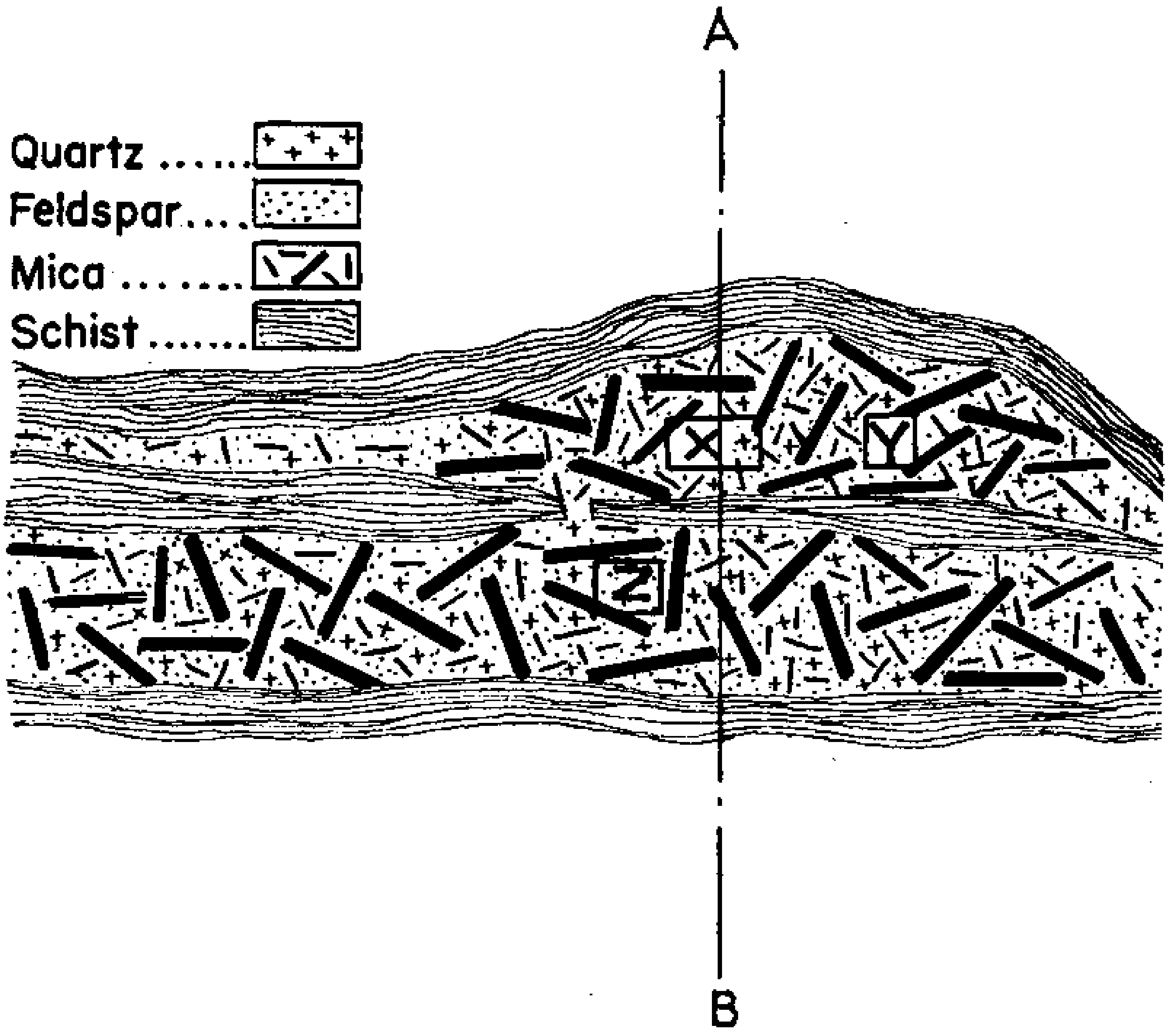

FIG. 9*B*. A 9-in. layer of schist concealed a rich vein that was found by raising at point *Z*.

A raise has also been put from the point *Y* (Fig. 9*B*), the roof of level 4. After 4 ft. of advance suddenly two layers of schist appeared on the face, dividing the vein into three sections, and robbing it of about 70 per cent of its concentration.

Massive Veins. Massive veins are much wider than most lenticular veins, with irregular distributions of mica throughout the mass. Working massive veins at times becomes exceedingly difficult, for they are generally less productive, but often the production from such veins predominates in larger grades of mica. Figure 10 represents a typical massive vein.

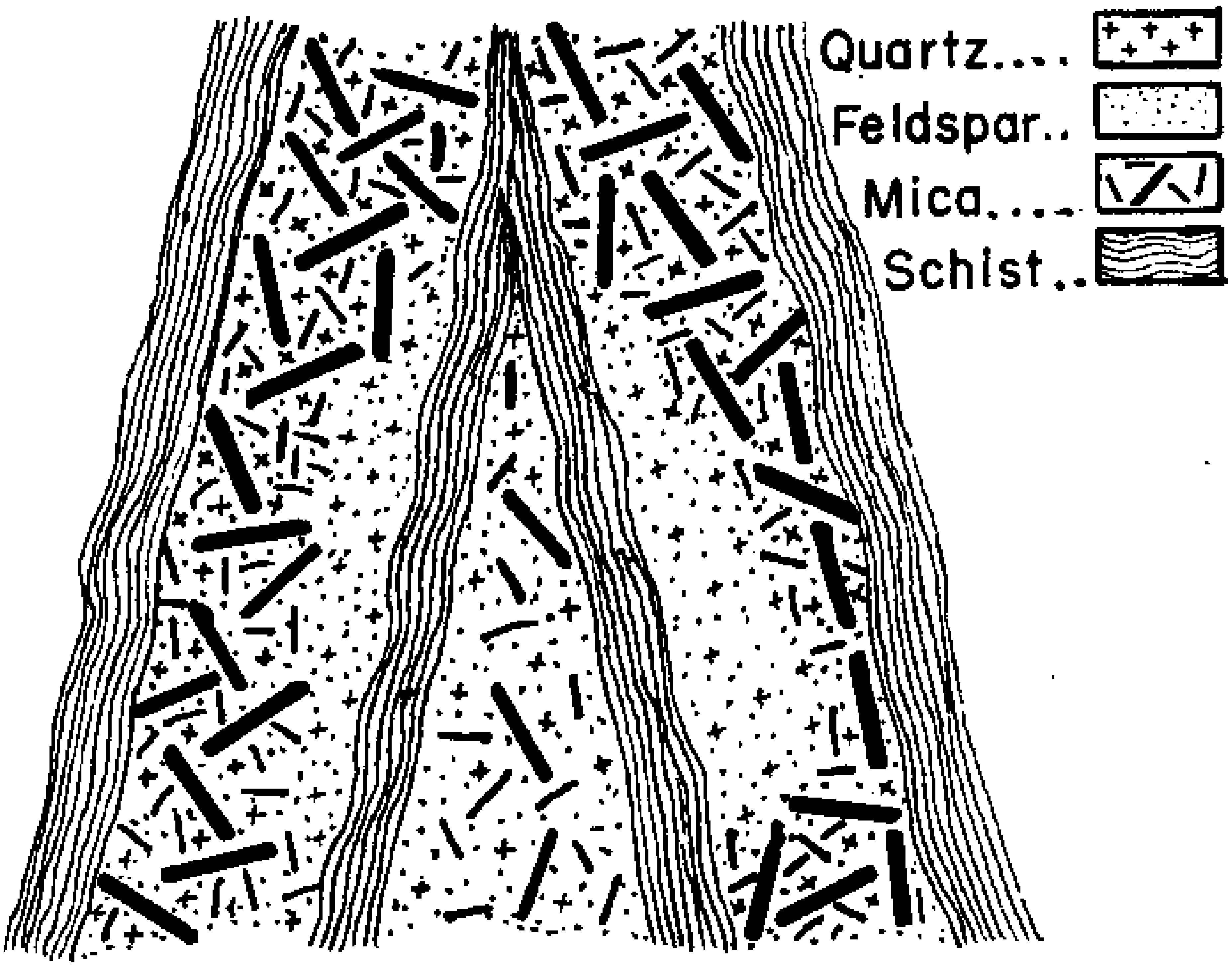

FIG. 9C. The vertical cross section of the vein between levels 4 and 5 developed in the manner shown above.

Pipe Veins. Pipe veins are more or less similar to lenticular veins running to a considerable extent along the dip but to an extremely limited extent along the strike. The productive zone along the strike usually does not exceed 50 or 60 ft., but these veins are generally found to be exceptionally rich in large-size mica.

In 1925 my father worked a pipe vein in the Karmatand area near Khijuri in the Giridih subdivision. It was called the Patrahia mine and yielded mica in large quantities to a depth of 300 ft. along the dip, but only to an extent of 40 ft. on the average along the strike. Average bulk of the production was exceptionally rich in quality and size. Recently a mine of practically the same type was worked by Messrs. Jethmull Bhojraj in Parsabad. Figure 11 represents a typical pipe vein.

The Indian Mica Supply Co., Ltd., is working a vein of this type under the direction of the author. The mine is popularly known as the Amjokola mine and is located in the above-mentioned Karmatand area on the same strike as the Patrahia mine at a distance of about 700 ft. Although on the same strike, the quality and character of its product is entirely different from that of the Patrahia mine, the average size being practically the same or even better. It has been worked to a depth of about 700 ft. along the dip and the deepest section is still yielding substantial production. But throughout the entire depth the average length of the productive strike is not more than 30 ft.

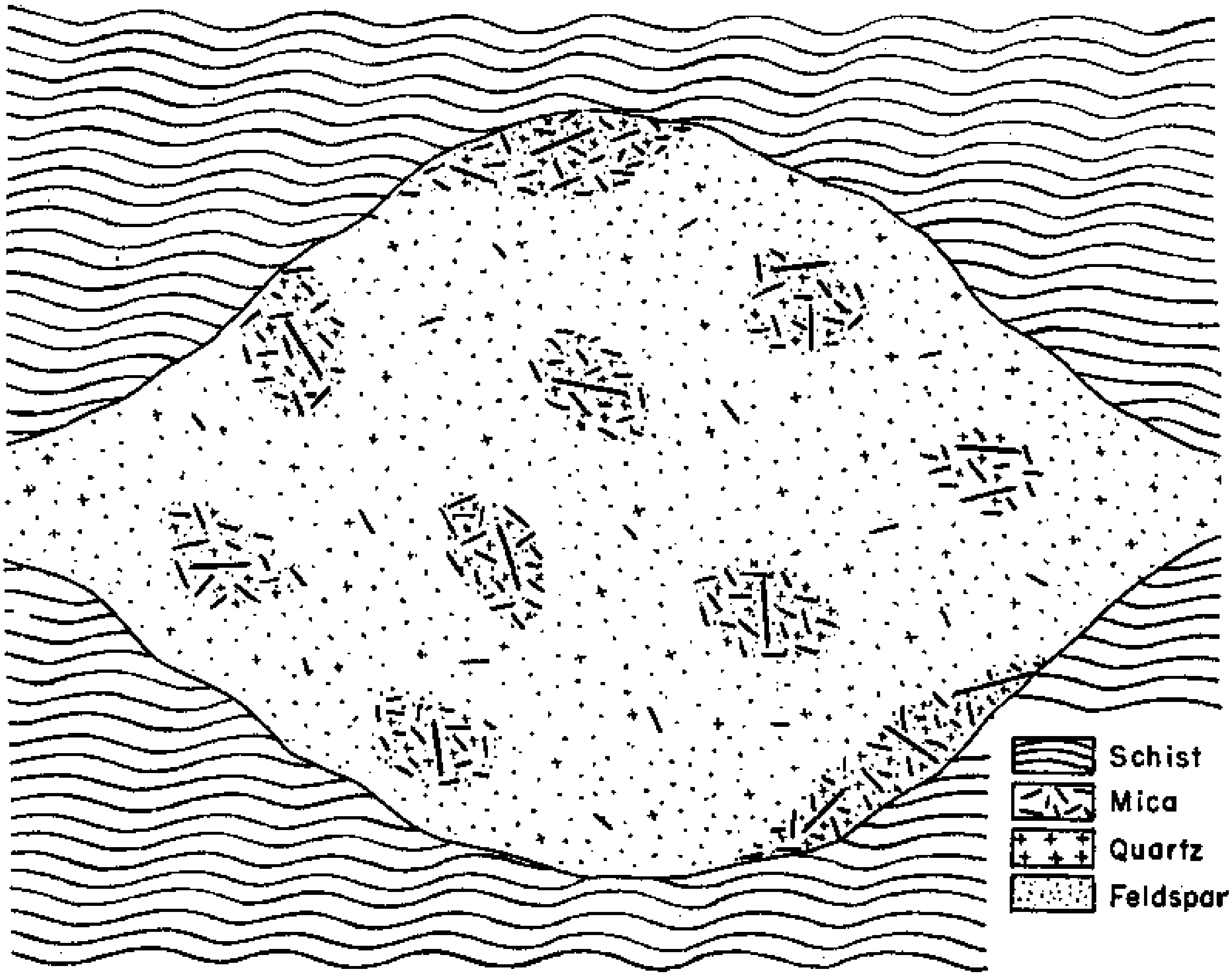

Fig. 10. A (hypothetical) sketch showing a horizontal projection of a typical massive pegmatite vein containing mica.

Banded Veins. These veins are generally similar to lenticular veins but are small pocket deposits practically on the surface, ex-tending to a depth of 40 or 50 ft. along the dip. They have been termed "banded" because in the small pits their cross sections show

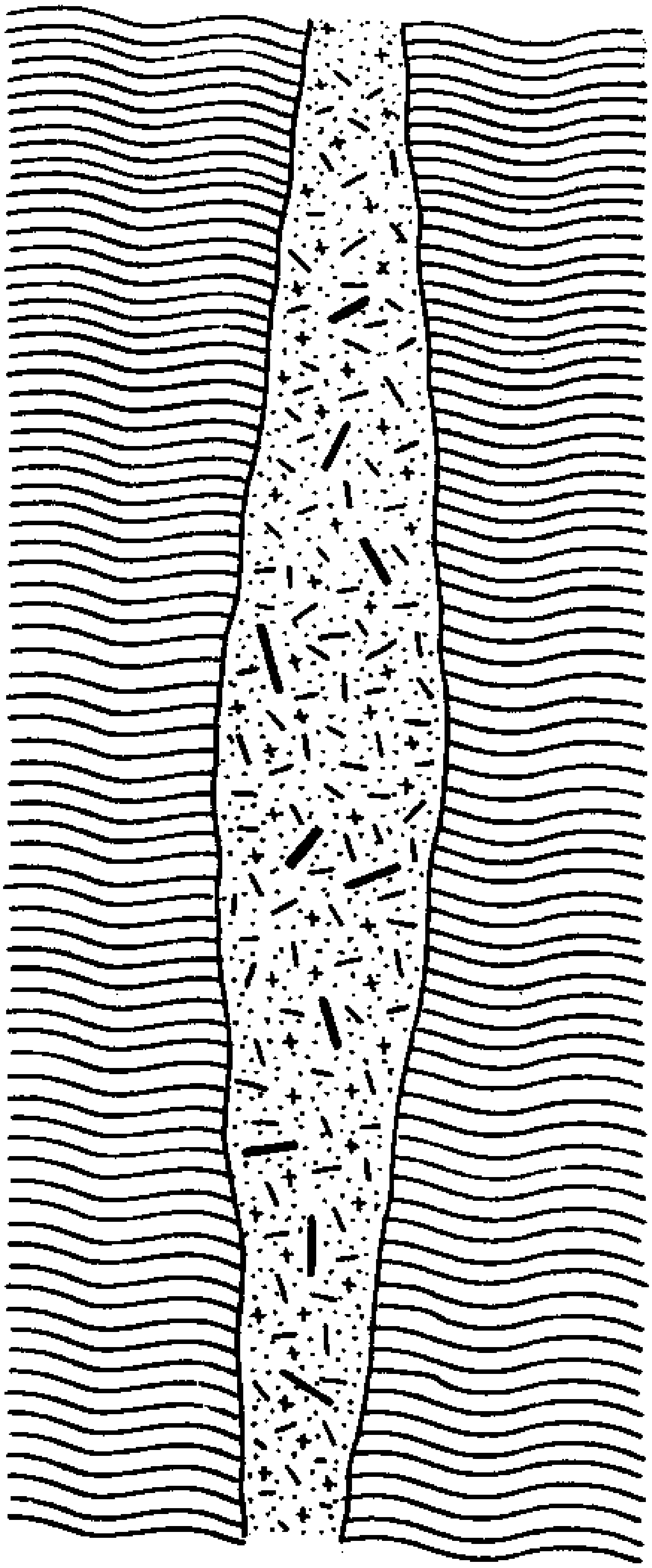

Fig. 11. A (hypothetical) vertical section of a typical pegmatite pipe vein containing mica.

a more or less banded arrangement of the productive zone and the quartz core, as shown in Fig. 12. In some areas there exists a series of such *en echelon* veins all having the same strike, as shown in Fig. 13. These veins are generally not very productive because of their shallowness, but the low cost of production allows a fair profit to an operator who knows how to exploit them efficiently.

Working of such veins does not call for mechanization. A few small hand pumps for removing water may be necessary in some cases. Generally mica of good size is not available in these veins. In most cases 95 per cent of the production consists of the lowest grades and the remaining 5 per cent medium grade, but in many instances the quality is superior.

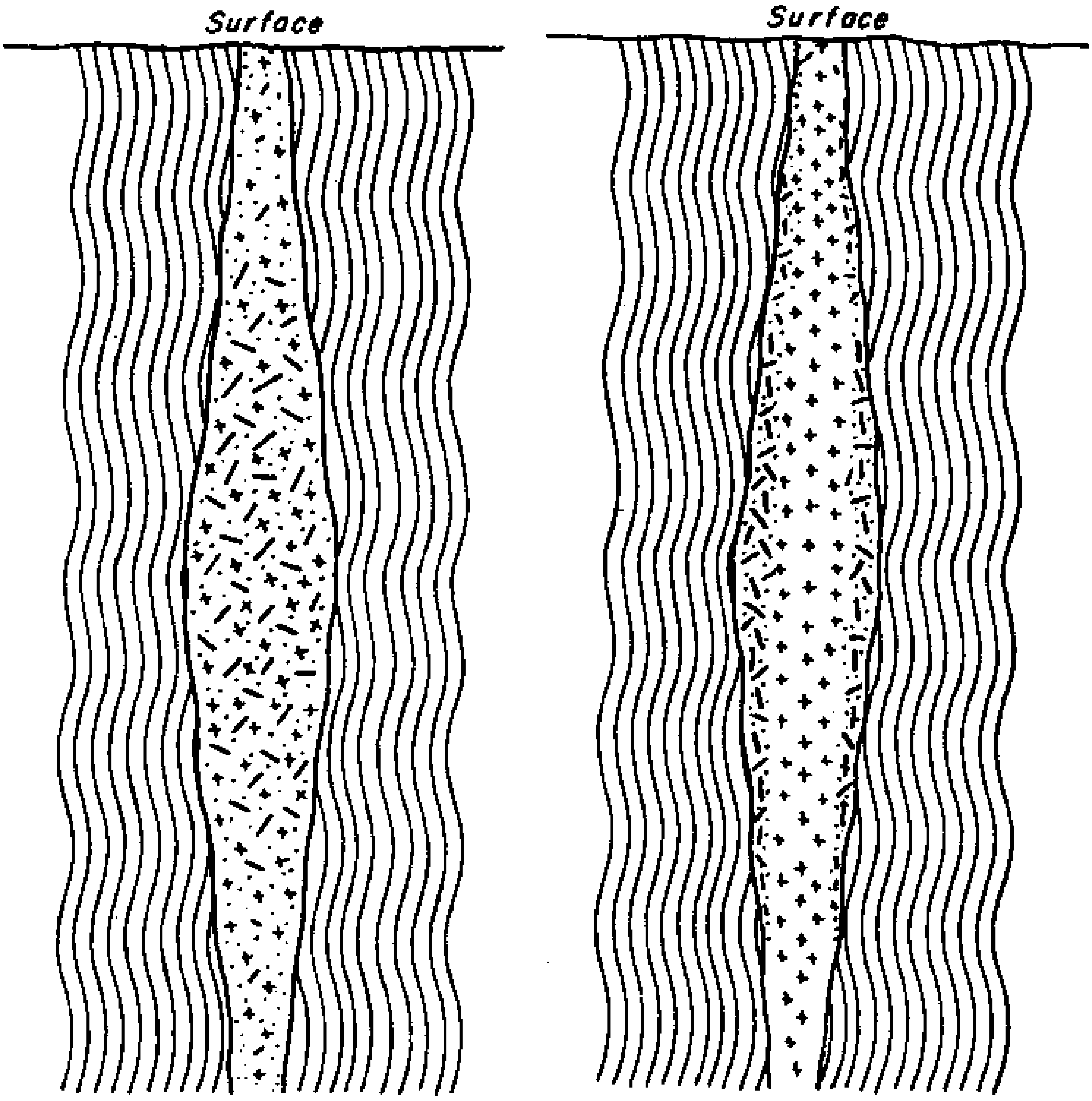

Fig. 12. A (hypothetical) sketch showing vertical cross section of two examples of banded veins. In the vein on the left mica is found disseminated throughout the vein, whereas the other vein has a core of quartz with mica concentrated along the contact of the schist.

The types of mica veins described are intended as a rough classification, based solely on the different nature and behaviour of these pegmatites. There is, of course, much overlapping between the pegmatites belonging to one group or another. At times it becomes extremely difficult to judge the nature and type of a pegmatite without extensive study.

In 1945, I started developing a mine in the Dhab area. It must be placed in the category of lenticular veins considering the productive zone near the hanging-wall schist. Results were obtained from a crosscut, which, after being driven about 140 ft., failed to reach the footwall schist and introduced an unusual amount of confusion to the entire project. This crosscut had already revealed the existence of about seven fairly productive veins, but unfortunately the mica obtained from these veins was hopelessly crushed and of practically no commercial value. This extraordinary thickness of the pegmatite containing a series of parallel veins was extremely baffling. Therefore, one cannot possibly venture a definite statement in regard to the mica-bearing pegmatites.

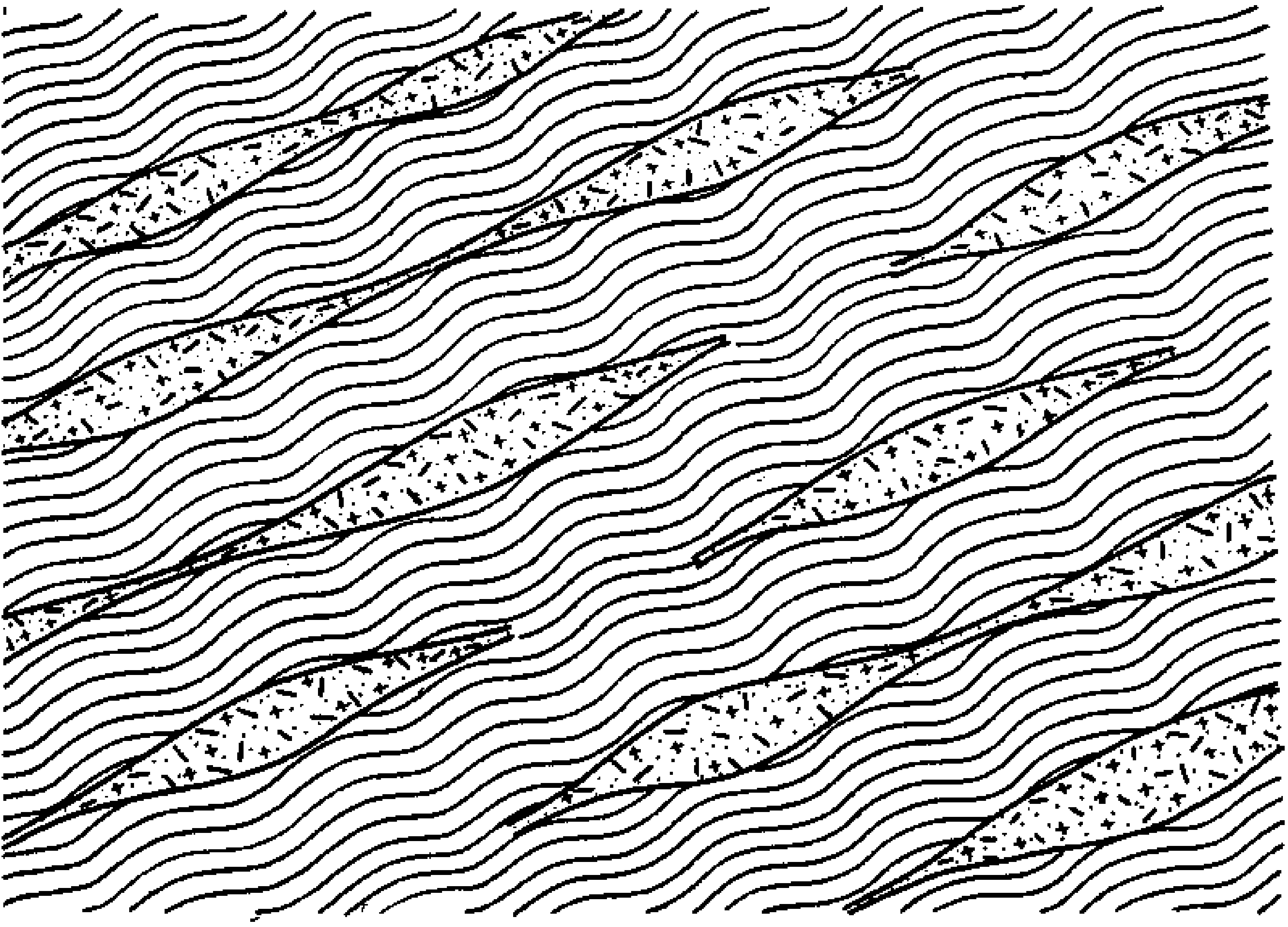

FIG. 13. A (hypothetical) sketch of banded veins *en echelon,* all having approximately the same strike.

The paucity of knowledge about these pegmatites is so great that, even in the bibliography of scientific institutions such as the Geological Survey of India, there exists little helpful information about the mysterious pegmatites. Therefore, even today the prospecting of mica may be said to fall beyond the scope of the present-day science of geology.

CHAPTER 3

Characteristics of Mica

Under the generic name "mica" are embraced, in a mineralogical sense, three groups of species possessing more or less similar characteristics.

1. The mica group, which comprises the micas proper.
2. The clintonite group, or brittle micas.
3. The chlorite group.

All these species are characterized by highly perfect basal cleavage and split easily into thin elastic laminae. They crystallize in the monoclinic system. The crystals are often of pseudo-hexagonal or pseudo-orthorhombic habit and exhibit, in many cases, twin structure.

Chemically, the micas are silicates of aluminum, with some water of combination, and contain one or more other elements, such as potassium and hydrogen, and often also magnesium, ferrous iron, and in some cases ferric iron, sodium, and lithium; further, in rare instances, barium and chromium. Fluorine is often present, while lime is seldom in evidence.

The members of groups 2 and 3, though of considerable geological importance because of their extensive occurrence as rock-forming minerals, have, however, not sufficient economic importance to require more than just a passing notice. We are concerned only with the "mica group," which consists of the following species:

1. Muscovite or potassium mica.
   $H_2KAl_3(SiO_4)_3$
2. Paragonite or sodium mica.
   $H_2NaAl_3(SiO_4)_3$
3. Lepidolite or lithium mica.
   $KLi[Al.2(OH, F)]Al(SiO_3)_3$

4. Phlogopite or magnesium mica.
   $H_2KMg_3Al(SiO_4)_3$?
5. Biotite or magnesium iron mica.
   $(H, K)_2(Mg, Fe)_2Al_2(SiO_4)_3$
6. Zinnwaldite or lithium iron mica.
   $Li_2K_2Fe_2Al_4Si_7O_{24}$
7. Lepidomelane or iron mica.
   $(H, K)_2Fe_3(Fe, Al)_4(SiO_4)_5$?

In addition to the above the following less important minerals may be mentioned as belonging to the group of the micas proper:

1. Alurgite, a manganese mica.
2. Roscoelite, a vanadium mica of doubtful formula.
3. Coellacherite-barytes-mica.

The composition of many of the micas is not definitely understood and the formulae assigned to them are only approximate. Of all the above species, muscovite is the most important from the electrotechnical point of view; though phlogopite, having stronger heat resistance than muscovite, has also gained considerable popularity in the electrical industries. These are the only two members of the "micas proper" which are valuable from a commercial standpoint. However, muscovite being the main variety dealt with in the mica industry of India, the discussions hereafter will be confined mainly to this member of the mica group. Table 1 shows analyses of muscovite and phlogopite.

Owing to the fact that most micas contain quantities of minute inclusions of foreign minerals, which may affect the analyses, and also that, in most cases, the equivalent elements replace each other in some degree, the results obtained are seldom found to agree with the theoretical compositions.

Mica owes its usefulness to an unique combination of a number of physical, chemical, thermal, and dielectric properties, which make it almost irreplaceable by any natural or synthetic product, especially in the electrotechnical industries. The most important physical property contributing to the great growth of the present-day mica-splitting industry that is the backbone of the modern mica-mining industry in India is its perfect basal cleavage. This property enables it to lend itself to easy and accurate splitting into superbly thin sheets or films of any specified thickness. The perfection of its laminated structure can be appreciated from the fact that it can be split into flexible and transparent films as thin as 0.00025 in.,

TABLE 1

TYPICAL ANALYSES OF THE TWO IMPORTANT TYPES OF MICA, MUSCOVITE AND PHLOGOPITE *

	Muscovite,† *per cent*	*Phlogopite,*‡ *per cent*
SiO_2 (silica)	45.57	39.66
Al_2O_3 (alumina)	36.72	17.00
Fe_2O_3 (ferric oxide)	0.95	0.27
FeO (ferrous oxide)	1.28	0.20
K_2O (potassium oxide)	8.81	9.97
Na_2O (sodium oxide)	0.62	0.60
MgO (magnesium oxide)	0.38	26.49
CaO (calcium oxide)	0.21	
Li_2O (lithium oxide)	0.19	
TiO_2 (titanium oxide)	.....	0.56
F (fluorine)	0.15	2.24
BaO (barium oxide)	.....	0.62
Water (combined)	5.05	2.99
Specific gravity §	2.75–3.00	2.78–2.85
Hardness §	2.00–2.50	2.50–3.00
Crystal system §	(¶)	(¶)
Cleavage §	(‖)	(**)

* Source: United States Tariff Comission report, "The Mica Industry," p. 10.

† Edward S. Dana, "Bengal (India) muscovite."

‡ Edward S. Dana, "Canadian (Ontario) phlogopite."

§ Edward S. Dana, "Text Book of Mineralogy" (1898).

¶ Monoclinic.

‖ Basal: eminent.

** Basal: highly eminent.

or ¼ mil, though the minimum thickness so far required for all practical purposes has not exceeded 0.0005 in. (½ mil).

TRANSPARENCY

Mica is generally understood to be transparent and it is so in thin sheets. Its transparency is inversely proportional to its thickness. Beyond a certain thickness, the transparency diminishes so that it becomes translucent and ultimately absolutely opaque.

The transparency of mica varies inversely not only with the factor of thickness, but also with the amount of air inclusions, commercially known as "silver stains." Heavily silver stained pieces are found to be almost opaque even in thin sheets. There are a number of other natural defects also impairing this particular property, such as lack of soundness because of cross graining, vegetable stains, metallic stains, spots or specks, which like silver stains (air inclusions) beyond a certain limit render it nearly opaque even in thin sheets. These defects have a very wide range of variation. It is, however, interesting to note that such defects are not found uniformly distributed throughout the thickness of a "book" (crystal) of mica, and by splitting a sound piece of even very heavily stained mica, one may recover a few absolutely transparent films.

FLEXIBILITY

The flexibility of mica also varies inversely with its thickness, and, beyond a certain limit, mica loses its flexible character wholly. A thin film of about 1 mil (0.001 in.) thickness can very easily be rolled round a rod of about ⅛ in. diameter without cracking.

THERMAL PROPERTIES

For all common purposes, mica is infusible and melts only at a very high temperature. Muscovite remains almost unchanged up to a red heat. It is an excellent heat resistant, *i.e.,* capable of withstanding very high temperatures without undergoing any physical or chemical change.

Besides this, mica can withstand sudden and wide variations of temperatures, without undergoing any appreciable damage to its physical character. This again is ascribed to its *volume constancy, i.e.*, freedom from contraction and expansion by virtue of its extremely low thermal coefficient. These thermal and other properties especially render mica irreplaceable by any other insulator in electrical machines where heat exceeding, say, 260°F. has to be met with.

DIELECTRIC PROPERTIES

Perhaps the most valuable property in making mica a commercial commodity of vital importance in the electrical industries is its latent and superb dielectric strength. It is incontrovertible that, without the happy collocation of most of the above-mentioned and other properties (to be discussed later), mica could not have secured its paramount position over other various available insulating materials. This important aspect of the subject finds little or no appreciation from those who produce mica in India, owing partly to a lack of domestic uses and partly to want of proper literature embodying all important details in a simple and concise form in respect to its electrical and other physical properties.

The ordinary meaning of the term "insulation" is universally understood and, as in the case of heat, cold, or moisture, applies to electricity as well. The function of an electrical insulator is to resist strongly the passage of an electric current. But the intensity of such resistance varies widely with various insulating materials. Some substances resist more strongly than others, and the resistance of any given substance varies with a number of factors. Pure dry air, for example, may be a perfect insulator under certain conditions, while it may be useless under other conditions. For practical purposes, we are concerned not only with the surface resistance, but also with the dielectric strength of an insulator.

The following observations made by the late Mr. Charles P. Steinmetz vividly elucidate and clarify the meaning of the term and the unique position that mica holds because of its dielectric strength.*

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* United States Tariff Commission report, "The Mica Industry."

> Take, for instance, two plates, put them against each other at a distance of, say, one-tenth of a millimeter—that is, 0.004 in. of air between them. Now, measure the resistance at, say, 100 volts difference of potential between the plates. It is infinitely high. For I do not think anybody ever measured the true resistance of air and found any other result than infinite. Now raise the potential difference between the plates to 500 volts. A spark will pass across the gap, and this insulating resistance, which a moment before was infinite, is now reduced to nil; it has broken down. Now, replace the air gap by a piece of dry fiber of the same thickness and measure again the insulating resistance in the usual way. You will find the resistance measurable, hence infinitely smaller than the resistance of your air gap. Still, you may raise the potential to 500 or 1,000 volts, and the fiber will stand the pressure. It will break down under a stress of about 1,300 volts. Now, replace the fiber sheet with a sheet of mica. The resistance is very much smaller than the resistance of the fiber, to say nothing of the air. But you may raise the difference of potential at the terminals to 10,000 or 20,000 volts and the mica sheet will stand it. The electricity will rush out from the terminal plates upon the mica sheet in long, glowing streamers, beating against the mica with a hissing noise and forming a broad electrostatic aurora of violet light, and still the mica will not break down. This (dielectric strength) is the property we want, but this disruptive strength has nothing to do with insulating resistance.

There are several insulating materials with higher specific resistance value than mica, which could be very preferably used, if they also embodied such other characteristics as infusibility, flexibility, and thinness of laminae. But none of these equals mica in dielectric strength. This is shown in Table 2.

Besides mica, there are many kinds of paper and cloth impregnated with various oils and bituminous substances, which differ from each other in their insulating values. Hence, the tabulation shown in Table 2 may be regarded as sketchy, but the table gives a correct impression of the outstanding superiority of mica as regards its breakdown or dielectric strength. A perusal of the table establishes the fact that the resistance or insulating value of practically all the materials mentioned is relatively high and the lowest is high enough for nearly all uses. However, the figures clearly show that mica is unique in its combination of electrical resistance and unequaled dielectric strength.

With the same insulating value and dielectric strength, the prefer-

TABLE 2

ELECTRIC RESISTANCE AND DIELECTRIC STRENGTH OF VARIOUS FLEXIBLE INSULATORS

Insulating material	*Resistance, megohms per sq. in. per mil of thickness*	*Dielectric strength, volts per mil of thickness*
Paraffined paper	11,800,000	900
Cotton, single covering soaked in paraffin	11,800,000	400
Rubber sheet	3,000,000	400
Micanite paper (1 or 2 layers of mica splittings on paper)	500,000	300
Micanite cloth (flexible)	440,000	200
Micanite plate, flexible "B"	320,000	600
Mica	33,000 *	3,000 †
Oiled paper, double coat	1,600	700
Asbestos and muslin, oiled	850	375
Oiled cloth	650	500

* This figure evidently applies only to a very poor quality of stained mica. Numerous modern authorities attribute to better qualities a resistivity ranging from 10^9 to 200×10^9 megohms per sq. cm. 1 cm. thick. Converted to terms of megohms per square inch, per mil of thickness (the measure used by Fowler in this table, adapted from his "Electrical Engineers' Handbook"), such factors would be about 400,000 to 80,000,000 megohms. Wide variations in this value may also occur even on the same sample, owing entirely to conditioning of the test sample. For ordinary electric insulation purposes, the highest resistivity values are not called for.

† The dielectric strength per mil of thickness ranges from about 5,500 volts when tested at 1 mil with spherical electrodes, to 1,300 volts per mil when tested at 9 mils of thickness. When tested with 2-in. plate electrodes, the value ranges from 60 to 75 per cent of the above figures.

ence between two materials is governed solely by the degree of heat that must be withstood. Any substance that chars, cracks, swells, shrinks, softens, or disintegrates at a temperature of 125°C. (257°F.) or less cannot be termed a first-class insulator in certain important machines. Hence, practically all organic substances, such as paper, silk, or cotton, which are prone to these changes, are of no use for insulating purposes. Other organic materials also, such as paraffin, asphalt, and various oils, with which paper and cloth are impregnated are not resistant to a temperature of 125°F. and upward, since they either soften, burn, or volatilize. It is evident, therefore, that, however efficacious and useful these organic materials may be as insulators—and their use is well established for many purposes—their scope of usefulness is considerably narrowed by the degree of heat to be met with.

The term "dielectric" represents a material with two distinct qualifications:

1. The attribute of possessing dielectric strength as explained above.

2. The capacity for momentary storage of electrostatic energy by induction instead of by conduction.

In a communication to the United States Tariff Commission, Mr. L. E. Barringer, Chief Engineer of Insulation, General Electric Company, Schenectady, New York, offers the most simple definition of the term "dielectric constant": "the ratio of the stored energy in the dielectric field [mica being in the dielectric field under discussion] to what would exist in the same space, if air were used in place of dielectric." *

Good-quality mica suitable for condenser uses possesses a dielectric constant ranging from 6.5 to 8, which means, roughly speaking, that it is capable of storing from 6.5 to 8 times as much electric energy as would the same volume of air. Table 3 gives the dielectric constants of some materials.

Last, but not least, is the extremely low power loss or power factor of mica, which makes it a perfect dielectric for condenser manufacturing. This element of power factor plays a very important part

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* United States Tariff Commission report, "The Mica Industry," p. 220.

in condenser service, the basic function of which is to store electrostatic energy in the dielectric field momentarily (perhaps one-millionth part of a second) and then to re-deliver it with the minimum possible loss. This loss is the measure of power factor and is entirely dependent on the type of dielectric used in a condenser.

TABLE 3 *

DIELECTRIC CONSTANTS OF SOME MATERIALS

Material	*Dielectric Constant*
Mica	6.5 to 8
Dry paper	About 2.5
Paraffin	2.3
Impregnated paper	3.0 to 3.8
Glass	Between 5 and 10
Porcelain	About 6.5

* Source: United States Tariff Commission report, "The Mica Industry," p. 22.

Though of vital importance, the factor of dielectric constant is seldom used in evaluating condenser mica, because mica that is otherwise suitable for condensers always possesses satisfactory dielectric constant (most probably due to its chemical stability). Thus it is the power factor or loss, as low as 0.02 to 0.04 per cent, that makes the use of mica practically indispensable in radio and other condensers designed to function under conditions of high voltage and frequency.

This invisible element of power factor decides the quality and ultimately assesses the value of comparatively higher quality mica (good stained and upward). The controversy that often arises in respect to the relative quality and, ultimately, the value of mica from different sources or of different colours has been attributed to the variation that is observed between their respective power factors, even though, under visual or even microscopic tests, some samples may appear to be of similar quality. What causes this vital difference, however, has not yet been ascertained.

Bihar ruby mica, of course, is fortunately placed in this respect. This is apparent from the manner in which supplies of split and manufactured condenser films or plates are being taken by consumers abroad. The bulk of ruby condenser mica produced by Bihar mica seems to maintain fairly uniform power factor. This fact is made obvious by the reluctance of foreign consumers to accept any green films, of practically identical or even better quality (according to visual test), with the exception of colour, in a mixture with Bihar ruby films. As a matter of fact, the inclusion of such green films is seriously objected to by many users of condenser mica.

This may be ascribed to the peculiar manner in which green mica is claimed to behave in respect to power factor. When measured at radio frequency, samples of even the highest quality clear green mica are believed to display an appreciable difference in power factor, which makes it unreliable for condenser use without an elaborate power factor test of each film.

It is perhaps as a result of this shortcoming that even the best quality green mica (commercially known as "first-quality green clear") is assessed at a much lower price than the best-but-one quality of the Bihar ruby mica (commercially known as "fair stained quality"). In certain sizes, according to the Joint Mica Mission's standard prices, this difference amounts to as much as 50 per cent. Precisely speaking, it is placed more or less at par with the good stained mica, which is the next lower quality to fair stained. Whether this difference (which may aptly be called "colossal") in its intrinsic value is really justifiable is, however, a bone of contention.

Until before World War II, this power factor could be determined only by highly technical tests. But during the war, the threatened short supply of condenser mica resulted in the efforts of the Bell Laboratories, of the United States, to conduct researches into the possibility of using a lower quality mica for condenser purposes. This ended in the invention of a portable, self-contained, battery-operated, direct-reading instrument for the determination of the power factor of mica, at a radio frequency as high as one megacycle or a million cycles.

Tests carried out with this apparatus tend to disprove the popular belief that only high-quality mica can satisfy condenser requirements. Samples of comparatively lower quality mica, considered as unsuitable for condenser purposes according to visual test, are said to possess amply low power factor, fully justifying their use as condenser mica. It is further claimed that 50 per cent of such rejected stuff could thus be found useful.

Though the results described above are unquestioned, the use of this portable test set—immensely beneficial to both the producers and the consumers of mica—has not yet gained ground or any appreciable popularity, for unknown reasons.

OTHER IMPORTANT PROPERTIES

Apart from the potentialities enumerated above, mica is chemically inert and stable and does not attract or absorb water. In addition to its being elastic, to all intents and purposes, it is practically noncompressible. A duplication of such properties is not found in any natural or artificial substance. Hence, mica is aptly called "nature's most useful curiosity."

The transparency of muscovite mica is inversely proportional to the thickness of the block or book. Thick books or crystals of mica are always coloured ruby or green, etc., and may be translucent up to thickness of 1½ to 2 in., but beyond this thickness the block is opaque.

There are, however, a number of common defects affecting the commercial value of mica. A crude book of mica will always yield a heterogeneous mixture of a number of grades and qualities, and it is only after a block or book is split (cleaved to a certain thickness) that the quality of a piece can be determined. Apart from a number of cracks caused by pressure or intrusion, inclusion, and penetration of fairly large-size crystals of quartz, garnet, beryl, etc., necessitating the division of a book into a number of pieces (Fig. 14), cross graining is one of the commonest defects (locally known as *Jatahi*), which impairs very seriously the most important attribute of mica, *viz.*, the feasibility of its being split into thin films. The defect renders it practically useless for electrical purposes except for punching washers.

At times distortions of crystals themselves cause irregular, striated, stepped, wavy, or corrugated surfaces, making mica absolutely useless for important electrotechnical work, where flatness is essential. Each of these defects beyond a certain limit is a detriment to even the lowest quality of mica. However much a piece of mica may fulfill all the other conditions, any one of the defects mentioned above is sufficient to render it unfit for high-voltage electrical work.

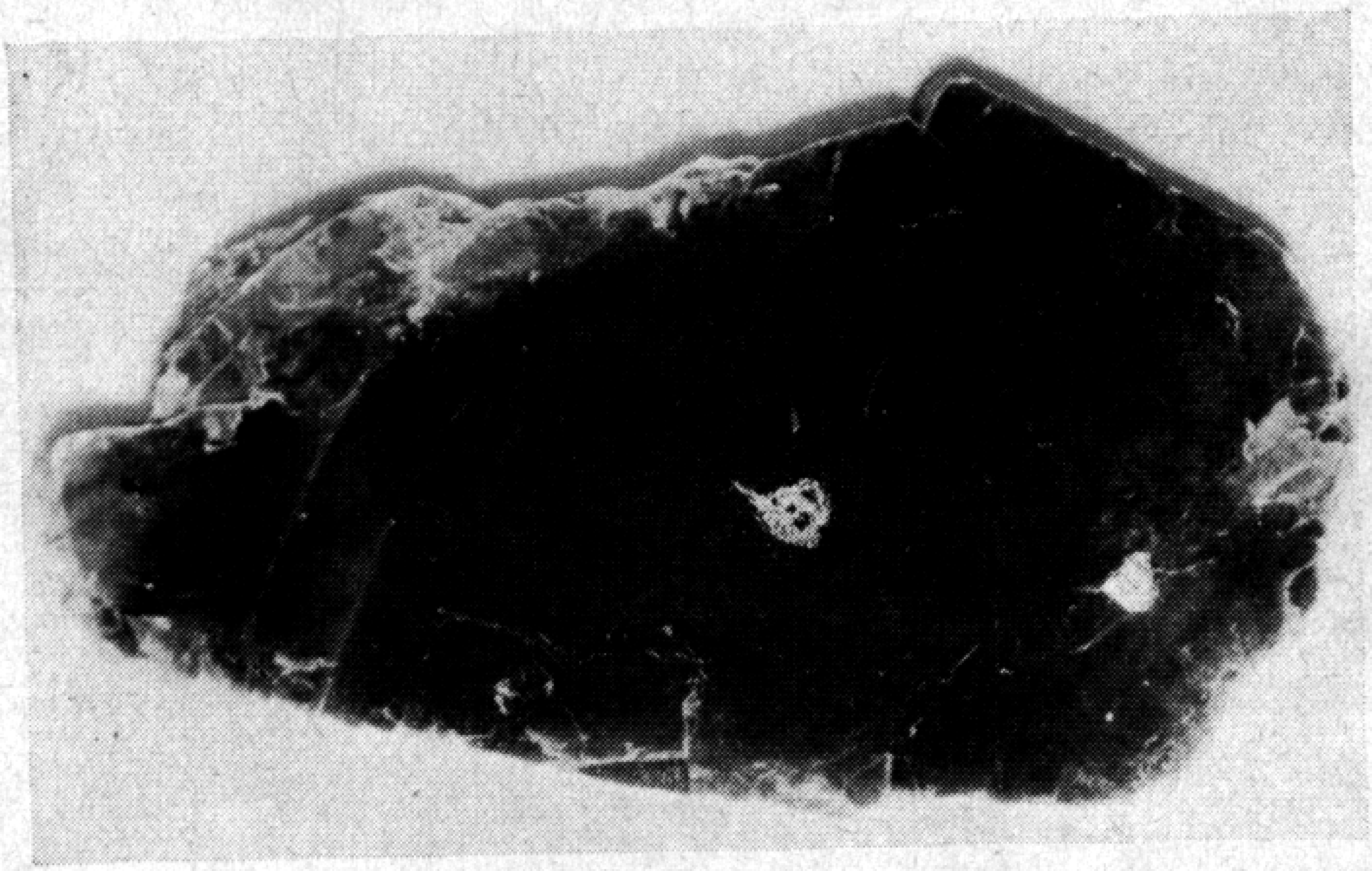

FIG. 14. Inclusions or intrusion of quartz or feldspar or any other associated mineral in this large piece of mica reduces its value by requiring its division into a number of pieces.

Thus flatness plays a very important part in determining the value of mica.

Besides these imperfections, which are mainly faults caused by cracks or by pressure and distortions of crystals during or after their formation, mica books are seriously affected by

1. The inclusion of foreign minerals that crystallize during the process of consolidation of the fluid to which they owe their origin. Such defects are characterized by black specks or spots caused by the inclusion of very thin films of tourmaline or biotite crystals and red specks or spots indicating the presence of iron.

2. Stains caused by the intrusion of other impurities like mud after the crystallization of mica. Such stains are commercially known as "vegetable stains."

3. The presence of pinholes, commercially known as "pin pits," caused by the penetration of minute crystals of garnet, quartz, or beryl.

4. Inclusion of air bubbles, commercially known as "silver stains."

All these defects are visible to the naked eye, and, from the point of view of high-voltage electrotechnical uses, as in condensers or capacitors, transformers, etc., the presence of metallic stains and pin pits is most objectionable.

As for vegetable stains, their presence in sound and hard mica is not so detrimental to its strategic importance, though beyond a certain limit it renders mica useless for condensers, transformers, etc. The presence of such stains within certain limits is tolerable for medium-quality mica such as stained quality, and one or two very light vegetable spots of reasonably small size are tolerated even in higher qualities like good stained, or even fair stained, provided such pieces are perfect in other respects.

The adverse effect of silver stains is roughly proportionate to the amount of such stains in a particular piece. The presence of a few minute air bubbles is not objectionable even in high-quality mica, such as slightly stained (S.S.) mica, and it is the presence of such stains in varying degrees that ultimately determines the quality of mica to a large extent.

Besides these, softness also impairs the commercial value of mica to a considerable extent. Beyond a certain limit, it renders it useless for any purpose other than employment in commutator segments or in the manufacture of splittings.

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CHAPTER 4

Mica Prospecting and Mining Leases

The prospecting of mica presents peculiar problems in which even the science of geology, in its present stage, does not yield conclusive help. The fact remains that from the time the mineral became commercially known, prospecting for mica has not advanced beyond the trial-and-error method. Some geologists might feel reluctant to call this feature a peculiarity of this industry, comparing it with conditions found in the case of small deposits of copper, lead, gold, etc., which in their opinion are similarly capricious and irregular in their occurrence. But if a close study of all these minerals is made, mica will be shown to be one of the most difficult minerals to find. We have to face the fact that, mica, so far as prospecting is concerned, stands apart from other minerals in regard to the risks involved.

In short, the only method known to the mica world is to sink a trial pit in a pegmatite and determine if a particular pegmatite is rich enough to be profitably developed. Considering all the pegmatites of the Bihar mica field, it can safely be said that, out of 100 pegmatites of average size, 97 or 98 produce disappointing results. Only two or three have so far been found rich enough to permit development on an extensive scale. The picture drawn is not so gloomy as it seems, for the one redeeming feature of mica prospecting is that it virtually amounts to working only shallow or surface deposits. Prospecting pits always yield some production, which in most cases allows a fair recovery of capital invested, provided the operations are undertaken by experienced persons familiar with these uncertain pegmatites.

The entire operation, however, is solely dependent on labourers who are born to the work of prospecting for mica veins and whose families have been doing the job for generations. These workers are so familiar with the mica pegmatites that they possess a sort of natural instinct for the search. It is these labourers who are the real finders of almost all the mica mines that were worked in the past and are being mined today. They go out in the field with a chisel and hammer, select a pegmatite, test it at different places until they hit upon what appears to them a productive zone, and then sink their trial pit. Such prospectors usually form groups of five or six men and work as contractors to the owners of the mining property.

This method of prospecting mica is locally known as "upperchella working." This is the only method known for prospecting mica in the mica world. It is followed by all companies, big and small, without any exception. Work is done mostly by contractors, who are invariably the labourers themselves. They are given the liberty of digging mica from anywhere within the limits of the property of an individual owner. Such labourers are paid for the mica they recover at fixed rates. Generally, the rates are fixed for all grades of S.D.B. mica.

Labourer contractors, after discovering a vein, start working it, following the mica from "book" to "book" (crystal to crystal) without a thought for systematic development. They do this partly because they are not paid for systematic development but chiefly because, even if they tried to do this, they would be faced with the irregularity of the distribution of mica in the pegmatite. They continue working the deposit as long as it pays. The moment it is found unprofitable, they abandon it and start searching for another. No one gives a thought to the pit thus abandoned until the property changes hands or management or there is an active demand for the smaller grades of both blocks and splittings, when lucrative prices warrant a more expensive and intensive search for mica. No one can claim to have maintained any record of such abandoned pits, a record that from a conservation point of view is most essential.

When some of these contractors are found to be producing considerable mica from a particular pit, the pit is inspected. If the vein is found promising, either the contractor is allowed to continue work as long as he can under stricter supervision of the management, or the pit is taken over immediately for working on a departmental basis, after ample remuneration has been given to the contractor. In the former case, when the pit is ultimately taken from the contractor, he is remunerated for having found a paying deposit. The pit is then developed in the deeper section and, if fortune favours, the party hits upon a good deposit, which ultimately develops into a big mine. At times a contractor is faced with barren ground at a certain depth, after recovering quantities of sound mica with good proportion of larger grades, warranting some amount of dead work before final abandonment. In such cases, if the work is to be continued by the contractor, he must be reasonably subsidized by the owner to cover at least the cost of such dead work. It is at these secondary stages of prospecting, which can be called "exploring," that one must make a large outlay and run the risk of losing considerable capital. But this is part of the game and unavoidable for a mica miner.

The risk involved in the secondary stage of prospecting may be reduced to a great extent by a careful study of the past history of the area in which the prospecting is done and its correlation with the prevailing conditions. For example, if in a particular area the number of fairly deep mines is very small and if it has been prospected by people with sufficient resources and experience, without much success, one should be very cautious about investing money in the area. There are many areas where considerable numbers of big mines have been developed and are in existence. In such areas exploring involves less risk.

The sudden discovery of a small pocket of mica of good size and quality near the surface invariably induces a high degree of optimism. Miners, big and small, experience this kind of optimism, which sometimes leads to an excessive amount of dead work, and, in the case of failure, investment is a total loss. Years of experience have established the fact that even in such cases the chances of success are rare. But whatever the facts may be, the appearance of large and good-quality books of mica, especially in a prospecting or upperchella pit, always supersedes all considerations of risks that lie ahead.

For example, here is a concrete case. In 1937, while camping in a mica area locally known as Luchmipur, I went out for an evening walk with one of my old sirdars (gang bosses) and the manager of that area. When we reached the top of a hill called Chandoia Pahari, my attention was caught by small chips of mica sticking to an outcrop of pegmatite. Some diggers were sent for from the pit near by and digging was started immediately. I sat there watching results with keen interest. After about a foot of earth was dug out, the pit started to yield large mica of remarkably good quality. It was such a sensation that there was no thought of dinner for any of us. Petromax lights (similar to Coleman gas lamps) were requisitioned from a mine near by and digging was continued without a break until midnight. A couple of feet below ground level, a very thick head of a book was revealed, and after an hour's hard struggle the entire book was recovered and weighed about 1½ maunds (about 130 lb.). After the recovery of this book the pit stopped yielding mica, though the work was continued for another hour with no encouraging results. Work was then stopped and was resumed again early next morning. But, though the pit was sunk to a depth of about 70 ft., with extensive crosscutting in both directions from the bottom of the pit, no further trace of mica could be found.

Only experience can enable one to appreciate the excitement that the sight of good books of mica removed from a prospecting pit or from a semi-established mine brings to both the labourer and the owner watching its recovery. Such occasional books do not add much to the bank balance of the owner, nor are the workers enriched to any considerable extent. But the amount of excitement created is extraordinary.

The "intuition" that they inherit in their blood, and which they subsequently develop through long experience and intimate knowledge of local conditions, places these upperchella workers well above the average geologist, especially one whose knowledge is confined to theories about the formation and occurrence of pegmatites. These theories are worth little until they are wedded to practical experience.

All the baffling intricacies of this subject, especially with regard to accurate forecasting of results, puzzle equally the geologist and the "intuition" of the upperchella worker. Neither can claim superiority over the other in this particular aspect of speculation. But the intuition of the upperchella worker must rank higher than the scientific knowledge of the geologist in locating the right place for a trial pit, then following the concentration of mica from book to book to the larger zones of concentration in workable pegmatite. Also he must foresee the contrary with dependable accuracy, thus avoiding unnecessary loss. Added to his native ability the upperchella worker has a peculiar love for the element of gamble involved in this adventurous way of earning a living, and this is indispensable in mica prospecting.

This class of labourer in Bihar always prefers to work as an upperchella contractor, provided the contracts are at suitable rates. It might be thought that no contract, however liberal, could place this class of labourer in a better position than the class which works in the mines on the basis of daily wages. But the former does earn distinctly more than the latter. This is fully substantiated by the continued adherence of these workers to this particular type of job, in which, as they say, they find the pleasure of excitement and the benefit of a higher level income.

More than half the total mining force of Bihar finds employment as upperchella workers. And, if Bihar does stand today in the forefront of the world's mica market, it is due entirely to their untiring efforts, their flair for this kind of work, and their congenital love of adventure in the prospecting of mica.

It will not be out of place to add that, until science finds a better way, it must be left to these upperchella workers to pave the path for posterity in the Indian mica fields.

Some geologists who pay but casual visits to the mica field might argue that the presence of certain minerals in the pegmatites is a healthy sign indicating a rich deposit of mica in the vicinity. Such an argument is largely deduced from the scores of stories current in the mica field, all stories of the same kind, which relate the presence of certain minerals to concentration of mica a little distance ahead. It is the belief of some geologists that all commercially workable pegmatites show a "backbone" of quartz, *i.e.,* show a considerable amount of quartz at the outcrop. Pegmatites consisting of red feldspar (orthoclase) do not provide an indication for muscovite. It is an indication for biotite or black mica.

No one, however, has yet been able to find a "backbone" in the mica pegmatite world that is a sure index to success in prospecting. There are many pegmatites in Bihar with a very prominent outcrop of quartz that on testing have been found completely barren from a commercial point of view. I have personally worked a number of mines that did not show quartz on the surface as an outcrop or underground in any prominent amount, but it should have been there according to theory, since I found an exceptionally rich deposit of mica. It is uncontestable that quartz is one of the three principal constituents of pegmatites; therefore, a prominent outcrop of quartz is not to be ignored. In fact, upperchella workers are guided considerably in their search for mica by this circumstance.

The relation of biotite to orthoclase cannot be taken as an axiomatic truth. Many pegmatites yielding muscovite without appreciable presence of red feldspar (orthoclase or microcline) have been found to contain a remarkable predominance of biotite. In a mine called Bhura in the Government Reserve Forest, though there is a very prominent massive quartz body and little or no red feldspar present, the mica-bearing zone down to a vertical depth of 70 ft. consists of a rich deposit of mostly biotite with little muscovite. Occasionally some books of muscovite are found that are generally large in size.

The existence of *kazra* quartz (smoky quartz) and *jogni* * has been claimed as a sure sign of rich deposits of muscovite in a pegmatite. This is explained by the theory of muscovite formation, that muscovite was formed as a result of considerable chemical reaction accompanied by a replacement phenomenon that occurred between the earlier formed orthoclase crystals and the acid plagioclase waters which penetrated after the orthoclase crystallization. As a result of this interaction between the orthoclase and acid plagioclase the separation of muscovite *kazra* quartz and *jogni* took place. This

* The authority professing the importance of *jogni* describes it as colloidal quartz found in thin films inside a book of mica. But this is erroneous. Colloidal quartz is locally known as *charbi*. *Jogni* is a local term used for a type of brownish clay occasionally found in some mica veins.

theory allots the same parentage to muscovite mica, *kazra,* and *jogni.* Therefore, *kazra* quartz and *jogni* have definitely been claimed as a sure indication of large deposits of commercially workable mica. However, practical experience gives no more validity to this theory than to stories current in the Indian mica fields about the secret of accurate prospecting. I have personally come across many pegmatites with very prominent *kazra* quartz and *jogni* and practically no mica.

The discussion on this particular branch of the subject reminds me of the reply I got from a sirdar several years ago in regard to promising indications. In a mine named Lakargarha, at a depth of about 70 ft., a very rich, small pocket of mica was suddenly discovered, measuring about 10 by 8 ft. Unluckily, at a depth of about 80 ft. the vein pinched off to a thickness of only a few inches. I asked the old sirdar whether the partly decomposed albite with small crystals of tourmaline present in the stringer could tell us anything about the future possibilities of this particular vein. In reply he said, "With all the experience I have gathered in my forty years of constant association with the mica veins, all that I can say is that I will believe mica when I see it. These happy indications provide the necessary encouragement to carry on, but very few efforts have so far been crowned with success." The shaft was sunk deeper, following the stringer to a depth of about 120 ft. without satisfactory results. Ten years have passed, and all that time I have acquainted myself with many pegmatites, but I have not yet been able to change the viewpoint I derived from this good old sirdar of mine. To him I owe at least two of the biggest mines I have worked.

It is the concentration of mica and mica alone, with a reasonable amount of regularity, that may be deemed indicative of a bright future. To afford a clearer and more realistic understanding of this subject I shall cite another example where, in spite of all the best indications, a mine failed miserably in deeper sections though the first 100 ft. from the surface were exceptionally rich. This happened in the Harinchurwa mine in square 18 (*i*) in the Government Reserve Forest (which has been discussed in the chapter "Some Geological Considerations of Pegmatites").

The intrinsic worth of upperchella workers in following mica from book to book to a stable zone of concentration has not yet been realized by advocates of modern methods of mining. On the contrary, this method has been the subject of serious criticism by geologists and mining engineers, who obviously have had little experience with the realities and baffling intricacies encountered in mica prospecting. The so-called "unscientific" or "wasteful" method of prospecting is seen at its best when a very narrow zone of concentration sandwiched between considerable patches of barren associates is detected and followed up by these upperchella workers to the hidden treasure of mica.

To understand this better, let us refer to Fig. 15, which represents an approximate vertical projection of a mine that the author prospected and developed with upperchella workers. The patches *A, B,* and *C* in Fig. 15 were barren, consisting mostly of feldspar, with some concentration of mica in the narrow zones *a* and *b* prominently exposed in the outcrop. The upperchella workers selected place *b* on the surface and, by following mica from book to book in a zigzag way, reached zone *F,* where the concentration was considerably richer and more regular. The pit was then taken over for departmental work and the direction of the strike was determined. Levels were driven in both directions. After about 100 ft. of progress along the strike, regular production of generally good-sized mica was established. The mine was then systematized by sinking a vertical shaft from the surface to connect with the first level.

Now, instead of following the concentration from book to book, if a vertical pit had been sunk either from point *a* or from point *b* the entire pit would have been found barren after a few feet along the dip. If the first few feet had yielded sufficient production before reaching the barren rock to justify some amount of dead work, the pit would then have been sunk through barren ground to a certain depth, the limit being more or less fixed by the degree of concentration and the nature of mica recovered in the initial phase, as well as the general conditions prevailing in the particular area. In any case dead work cannot be recommended beyond, say, 15 to 20 ft. at most, during the early stage of prospecting.

After having sunk through the barren patch to the maximum permissible depth, if results are not encouraging the entire venture necessarily must be given up as a bad gamble. If the results obtained in the first few feet of sinking are encouraging, one must go to the extent of drifting along the strike before finally abandoning the pit. However, as shown in Fig. 15, the productive zone was practically sandwiched between considerable patches of barren feldspar and the drifts ceased to yield any production after a few feet of driving in both directions. This ultimate failure confirms pessimism, and in spite of the probable presence of a rich, deep mica deposit, the treasure would be lost forever as a result of trying the wrong method.

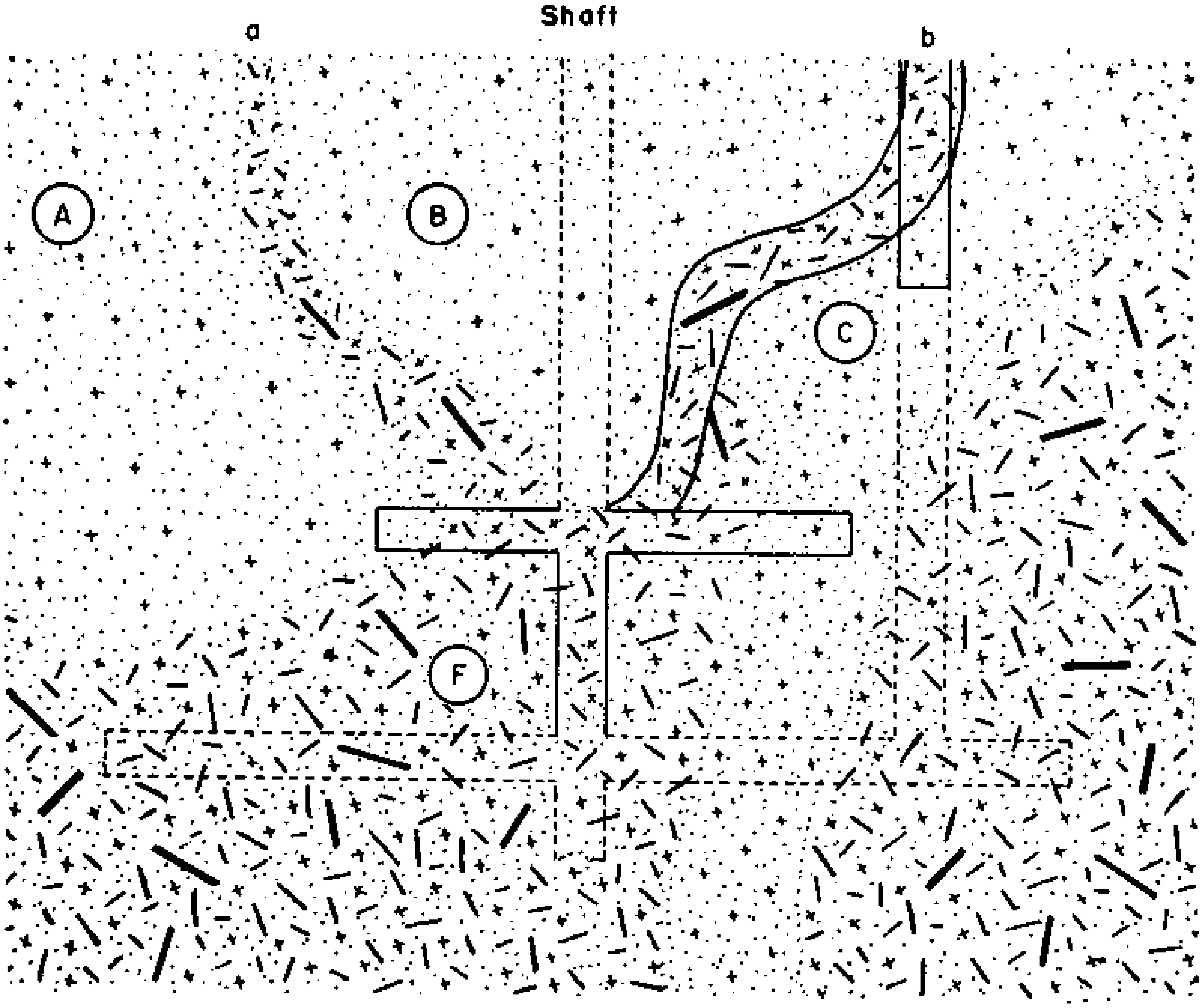


FIG. 15. This shows how it is impracticable to prospect mica veins through vertical shafts. Outcrop *b* was developed downward, following mica book to book in an irregular manner. When regular concentration was found in *F*, a systematic method of shaft sinking and development along the strike was undertaken.

I trust that enough has been said to show the impracticability of prospecting mica through vertical pits and that the public mind will be disabused of the notion that the method applied by the upperchella workers of the Bihar mica field should be condemned as unscientific.

The first few feet of sinking through a pegmatite gives an approximate indication of its future in the same manner that "the child shows the man and the morning the day." Even for the first 30 or 40 ft., if an upperchella worker gets mica just sufficient to cover his day's wages and the concentration of mica is more or less like that of plums in a pudding, it can very safely be concluded that it is one of many shallow deposits of no commercial importance. But at a depth of a few feet, say 15 or 20, if the concentration of mica assumes a regular trend and the trial pit starts yielding more or less regular production even in small quantities (enough to give the uppercella worker more than his day's wages), such pegmatite may be regarded as quite hopeful, and work in the deeper sections can be carried on by the workers with better prospects in view. Such pits carry better possibilities of improvement in depth than those which are found to be spotty and irregular even at 40 or 50 ft.

As an example, I cite the case of a mine that can justly be called one of India's richest. At about 20 ft. from the surface, along the hanging-wall side, the concentration of mica became very regular, though the width of the zone of concentration was only about a foot. For about 150 ft. along the dip, although the width of the productive zone increased gradually, the mine was not a paying proposition. Production consisted of mostly small sizes and practically half of it was worthless. When the fifth level was driven the productive zone increased in width with a remarkable improvement in the size and soundness of the average production and then continued to a vertical depth of more than 600 ft.

I worked another mine of a similar type, which yielded a substantial production to an incline depth of about 1,000 ft. from the outcrop. For 170 ft. approximately, I was faced with a number of small lenses along the dip. For more than a year, although the redemption of capital was not doubtful, neither was the prospect very bright. But soon after 170 ft., there was a sudden change in the vein that was extraordinary.

Apart from this popular method of mica prospecting by trial pits there is another, which is applicable only in the case of pegmatites outcropping at the top of steep hills of at least 70 or 80 ft. above the surface. In such places, where a number of shallow trial pits can be sunk along the strike, if they produce reasonably good results an adit can then be driven at an elevation that allows space for a dump should the project meet with success. This method is more profitable than sinking a pit or pits 70 to 80 ft. deep.

Such an adit serves the purpose both of sinking and of extensive crosscutting and provides the prospector with a clear picture of the entire cross section of the pegmatite or pegmatites (in case there are a number of pegmatites running parallel to each other), particularly at a considerable depth from the outcrop. Some might call this method expensive. But this is erroneous. To be clear on this point let us examine a specific case.

Figure 16 represents a vertical cross section of a hill about 80 ft. high. Three pegmatites are found outcropping on the sides and near the top of the hill at points *a, b,* and *c.* To get a complete picture of these pegmatites at about 70 ft. deep there are possibly three courses to follow, *viz.:*

1. Sink trial pits 70 ft. deep in all three pegmatites.
2. Sink a pit in the middle vein from point *b* and obtain a section of the other two veins by crosscutting from the bottom of the pit in both directions as shown.
3. Drive an adit across the hill from a suitable location a little above the surface level.

In the first case three pits of at least 6- by 6-ft. rock section must be sunk, totaling 210 ft. of shaft sinking. Assuming the average cost of sinking a 70-ft. pit of this type to be X per foot, the total cost of sinking three pits will be Rs.210/– times X under identical circumstances.

In the second case, the total work to be done will be 70 ft. of vertical sinking, plus 35 ft. of crosscutting in one direction, plus 25 ft. of crosscutting in the other direction.

As explained in the previous case, the cost of sinking the pit will be $70X$. But the cost of crosscutting will be more than the average cost of sinking, because the broken rock in this case must first be removed from the working face of the advancing crosscut and brought to the bottom of the pit and then hoisted to the surface. In practice it has been found to be about 33 per cent more than the average cost of sinking a pit. Under these circumstances, the total cost of sinking and crosscutting will be 70*X* plus 80*X* (the total length of crosscutting being equal to 60 ft.), or 150*X*.

In the third case, to obtain a complete picture of all the veins, even if one must drive an adit of 200 ft. the cost in any case will not be more than that of the other two cases, because in driving an adit (7 by 6 ft.) the average cost per foot of advance is about 33 per cent lower than the average cost of sinking a pit of any great depth. In such circumstances, the total cost of driving an adit 200 ft. in length will be 66 per cent of 200*X*, or 132*X*.

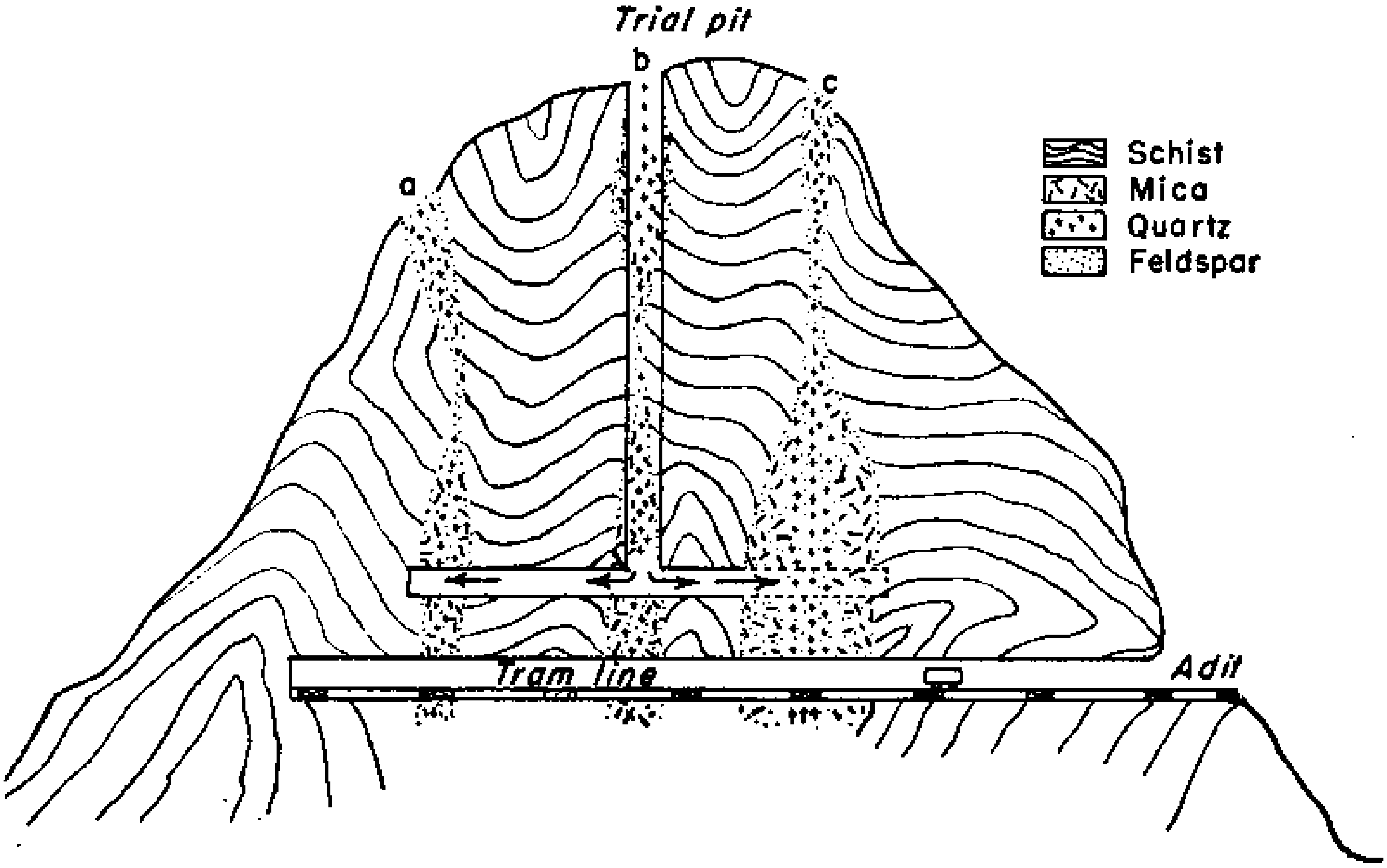


FIG. 16. Prospecting three or more pegmatites by an adit instead of first sinking a shaft on outcrop *b* has economical advantages in mica mining.

Apart from the difference in cost, the time factor involved in the first two cases is considerably more than in the last. Moreover, in the first two cases the number of labourers and the amount of equipment required are also more than those necessary to drive an adit. For example, if the broken rock must be hauled up by manual labour, at least 15 workers on an average will be required per shift just for cleaning debris. Otherwise power-driven or hand-driven mechanical arrangements must be provided for hoisting. In addition to the timber and labour required for securing the sides of the pit, platforms must be made at suitable intervals and strong ladders installed for the workmen. This ladderway must also be kept fenced by suitable timber for security. In case of drainage problems, arrangements must be made for pumping.

But if an adit is driven these difficulties can be avoided. The problem of removing the broken material is easily solved by the installation of rail lines and tubs or mine cars in the adit. A slight gradient is always allowed in an adit, so that the loaded tub may be easily pushed down the slope by one man, from the working face to the outside. There the tubs can be tipped and unloaded and then returned to the working face for the next load. As the length of the adit increases, ventilation may be necessary. This can be obtained by putting a rise from a suitable place, preferably through the first vein, provided it is reasonably productive. Rising presents no difficulty since the broken rock falls on the adit floor, where it can be easily loaded in the tubs and removed. Figure 16*A* shows a tub at the adit entry.

In some exceptional cases, rising may be difficult and connections have to be made by sinking from the top of the hill, which would increase the cost a bit. The difficulty of ventilation is encountered only when the length of the adit exceeds a certain limit.

It might be argued that this method is applicable only to cases where the number of shallow trial pits from the surface produced appreciable results and that the cost of the trial pits must be added to that of driving the adit. This is partly true. But this method of prospecting by driving an adit falls in the category of secondary-stage prospecting or exploring and the primary part of it is mostly done by upperchella workers on contract basis as already explained.

The cost of putting in trial pits, therefore, is not borne by the mining department and must be treated as falling completely outside its jurisdiction. Taking the worst view, even if the cost is equal to that in the first case or even a bit more, the amount of information that can be gained from adits fully justifies the expenditure. In case the venture is a success, systematic mining operations can be started right from the beginning.

I have personally tested a number of such steep hills in the manner described. Of five adits driven, three produced satisfactory results. The first adit was driven across a hill which was named Lalki No. 2 Pahari by the upperchella workers. Since 1939 prospecting was done by contractors on this hill, and the company's record showed a regular production of mica in small quantities. At the end of 1941 my assistant's annual report revealed the existence of a series of prospecting pits at the top of this hill, and since production from these pits was fairly regular, I issued instructions to drive an adit from a suitable location at least 10 ft. above the ground level. The adit touched the first vein at about 130 ft. and it was sufficiently rich

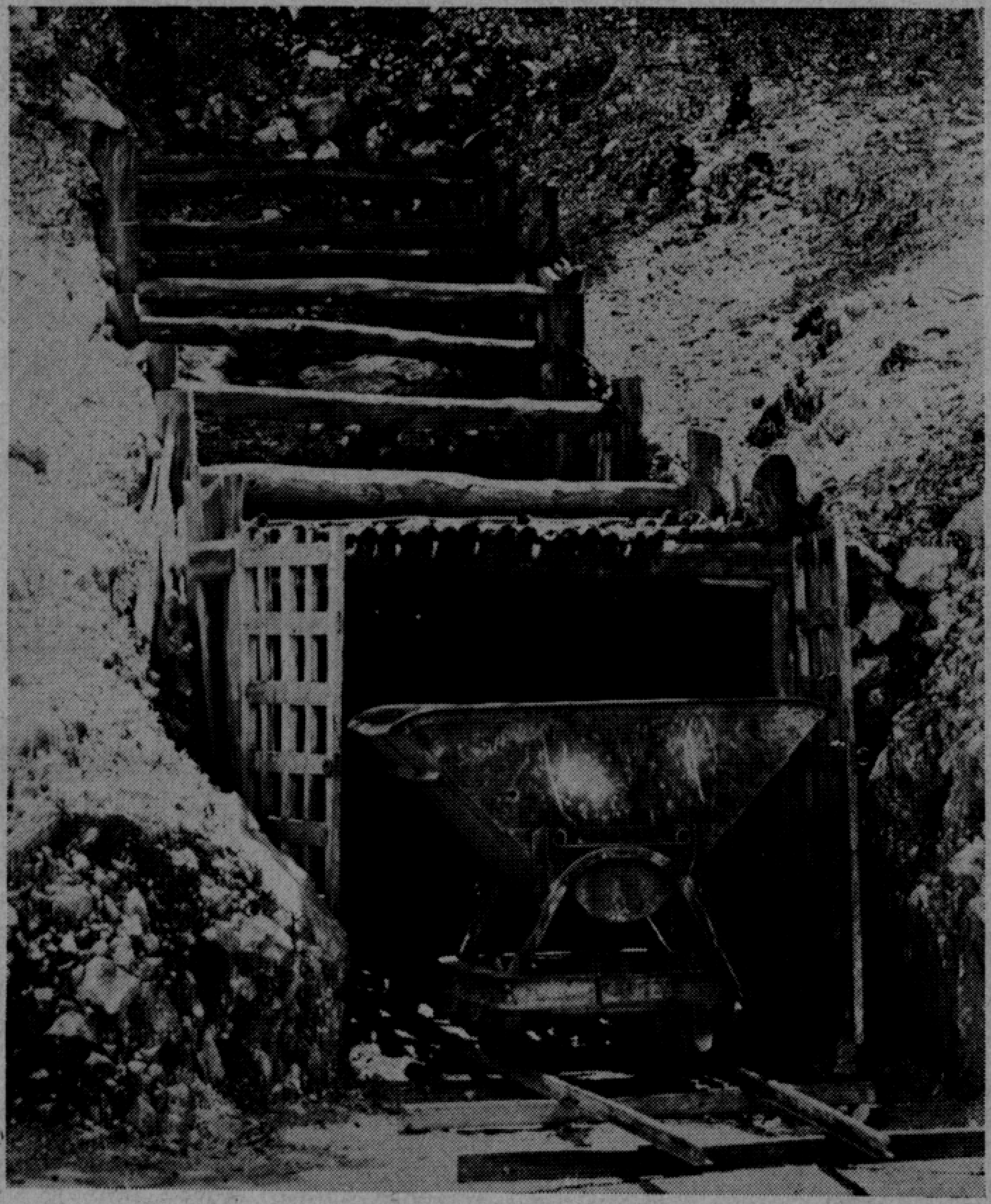
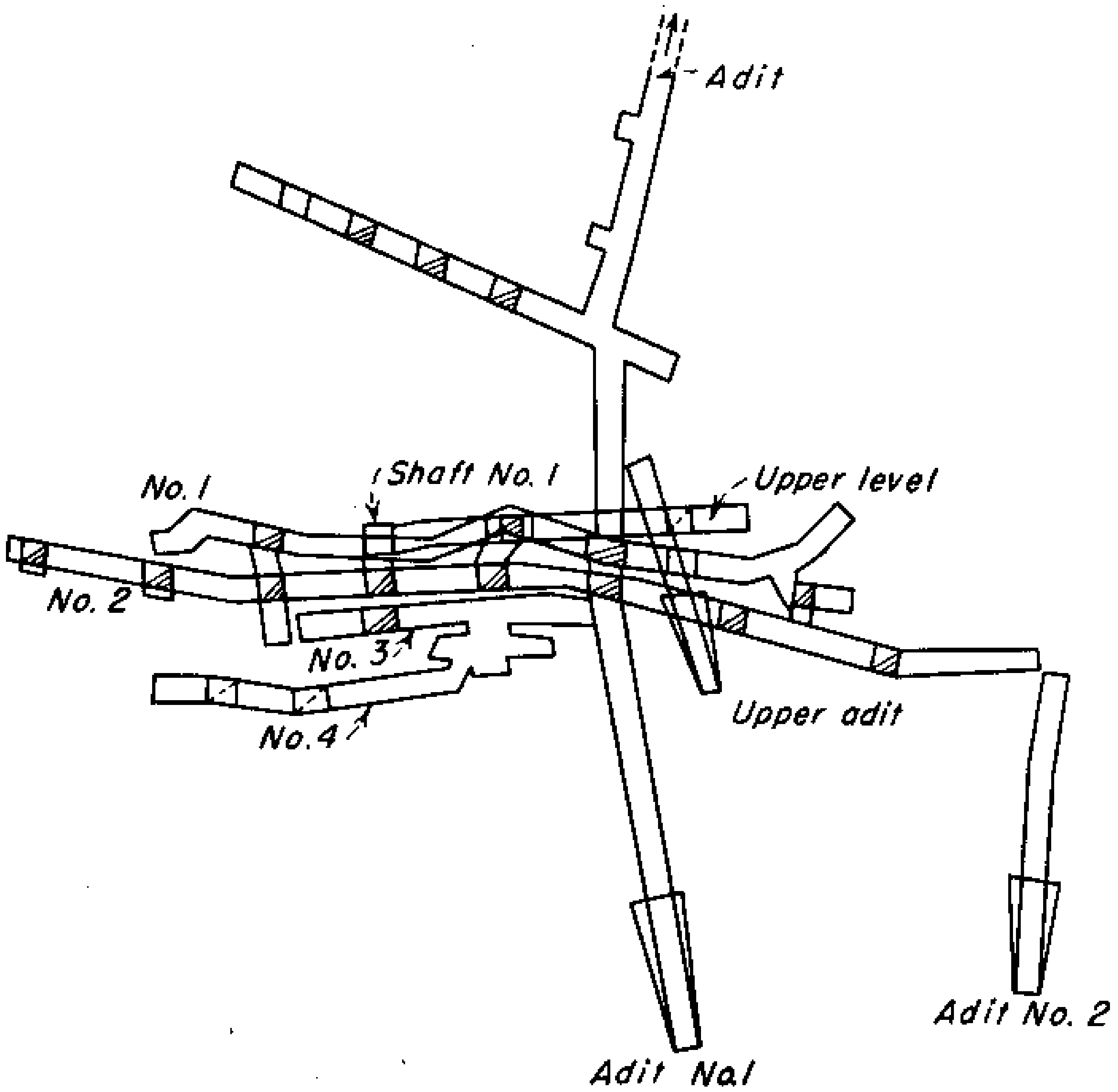
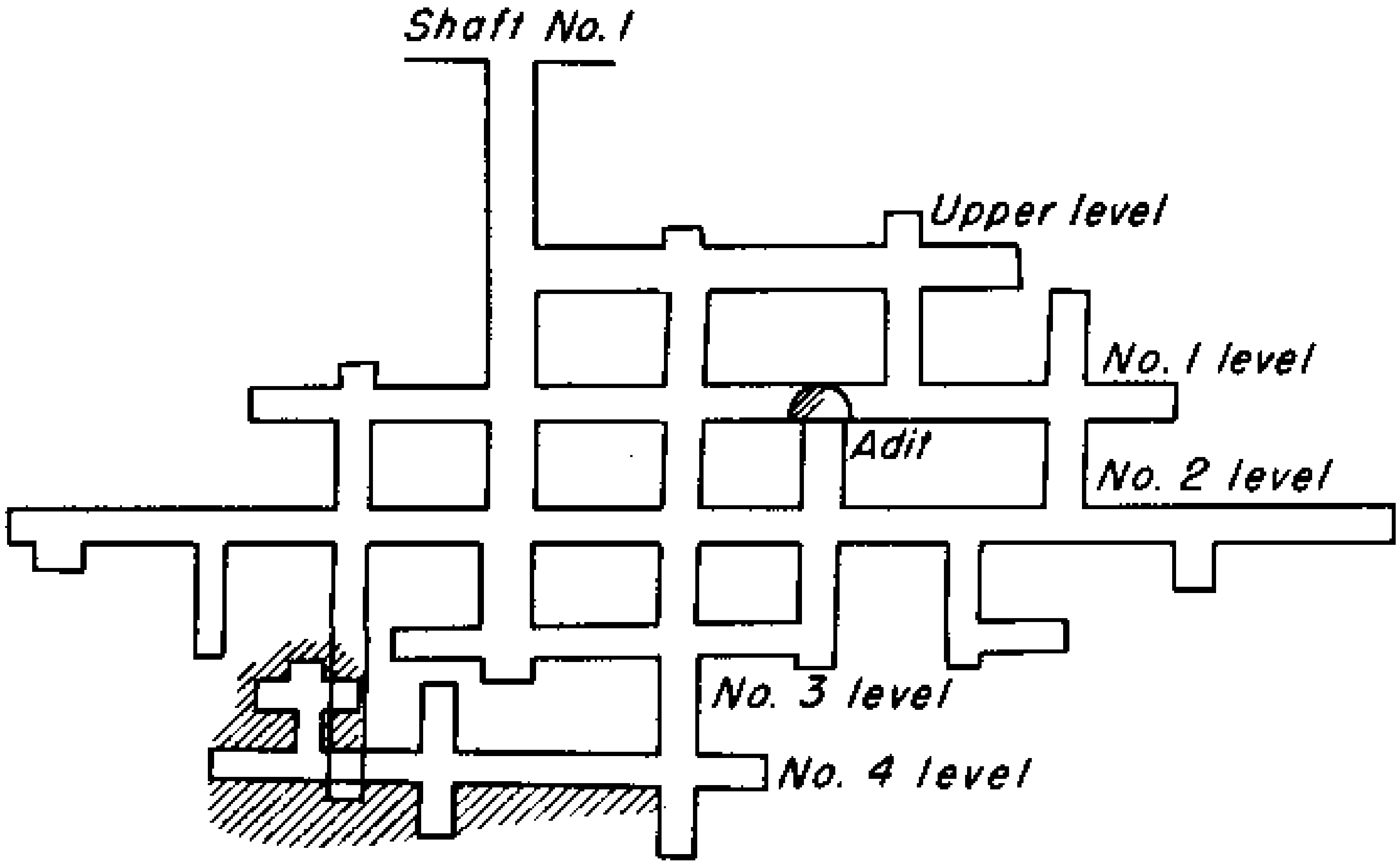


Fig. 16*A*. An adit entry of a mica mine.



Plan



Projection

FIG. 17. A plan and section of a mine of an important mica producer in the Bihar mica fields prospected by an adit and then developed in the usual manner.

and regular to justify systematic development on an extensive scale.

Levels were driven from the adit in both directions along the strike and development in the deeper sections was started. This mine yielded mica to a depth of about 130 ft., after which the vein pinched to 2 or 3 in. and finally vanished at another 40 ft. The average length of the productive strike was about 250 ft. In spite of the vein being reasonably large, it did not pay well since the average bulk of production was predominated by smaller grades.

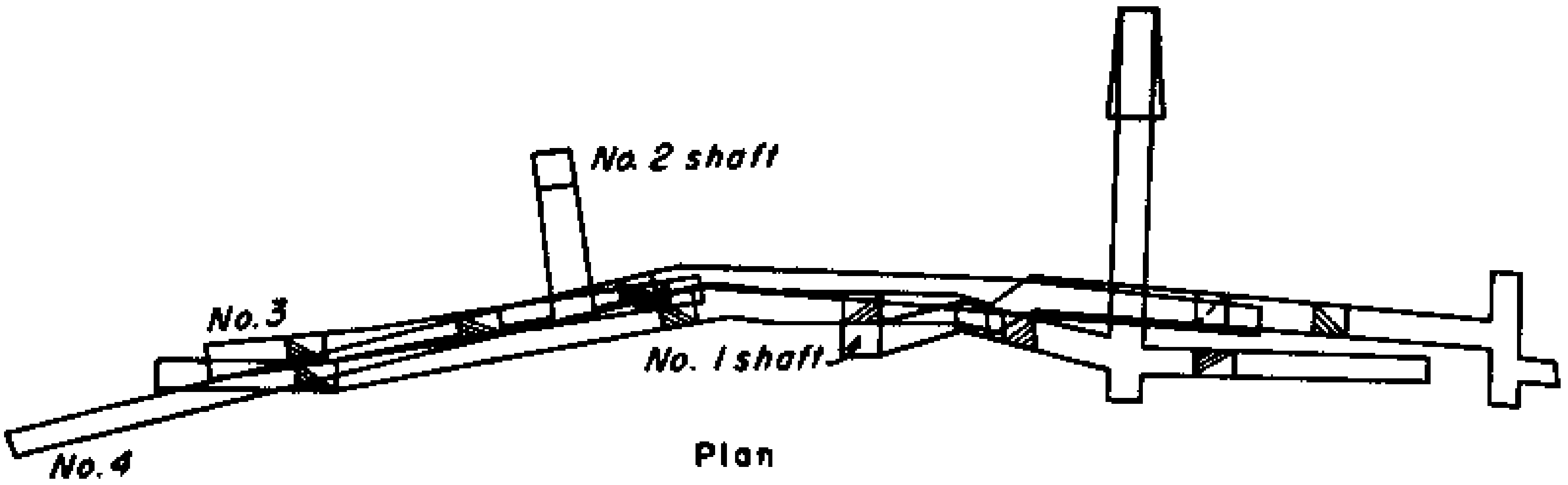
The adit was then driven farther. After about 50 ft. another vein was cut. Development was done along the strike for about 100 ft., and three winzes were sunk. But since the concentration of mica was too poor, economical development was not possible. However, the adit was driven farther, and at an interval of 20 or 30 ft. two more pegmatites were found but with no encouraging results. Figure 17 represents the plan and projection of the Lalki No. 2 Pahari mine.

Lalki No. 3 Pahari was also prospected in the same manner and the adit met the vein after about 80 ft. This particular vein was similar in nature to the one at Lalki No. 2 Pahari, but the average length of the productive strike in this case was about 500 ft. This yielded mica to a depth of 100 ft. from the adit level, after which the vein became less productive.

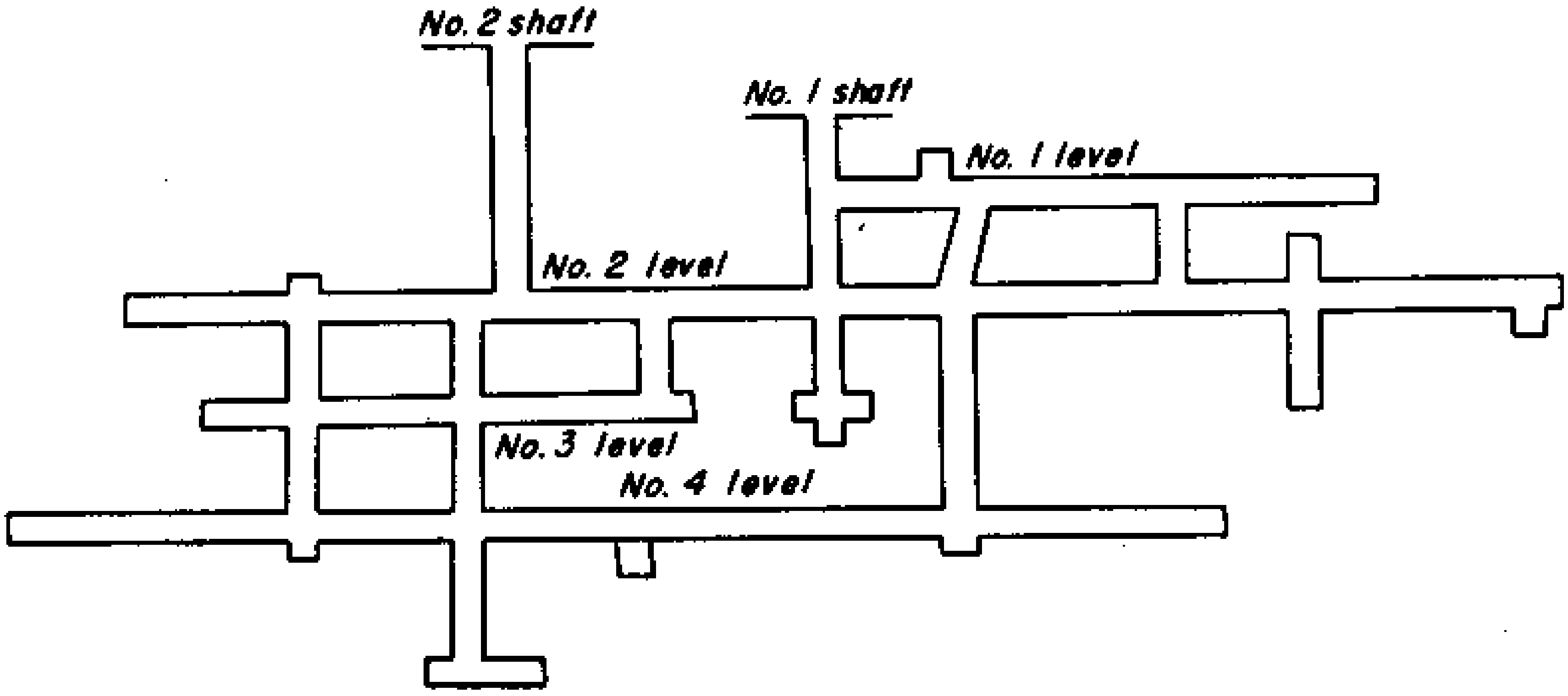
Total production obtained from this mine in 1 year was about 4,300 maunds (352,000 lb.) of crude, out of which only 200 maunds was of fairly large size. Nevertheless Lalki No. 3 Pahari turned out to be more profitable than Lalki No. 2 Pahari. Figure 18 represents the plan and projection of the Lalki No. 3 Pahari mine.

It has been found that if a vein allows reasonable development of 50 to 60 ft. along the strike at a depth of about 45 or 50 ft. from the outcrop, it is a better prospect than veins that do not permit even 15 or 20 ft. of development along the strike even if they are comparatively richer. In the former case, even if a mine fails to develop into a big one, the comparatively smaller development on the strike and dip allows a fair redemption of capital with reasonable profit.

In spite of all these facts obtained from continued observation, it must at all times be borne in mind that there is no telling for certain at any stage what may be developed. These pegmatites seem determined not to allow any categorical statement about either their richness or their poverty in mica. And, if one hazards a statement at all, it should never be taken seriously.



Plan



Projection

FIG. 18. A plan and section of another mine, which in one year produced about 4,300 maunds (352,000 lb.) of crude and was prospected and developed in the same manner as shown in Fig. 17.

No one would deny the geologist due credit for a number of theories as to the origin of pegmatites and as to how and under what conditions mica was formed as one of their principal constituents. The difference in views expressed by various authorities in no way affects the commercial angle. Some might argue that mica was directly crystallized out of the magmatic solution or the superheated water that was left as residue after the deposition of granite. Others, contesting the above theory, may say that muscovite is a result of interaction between the earlier formed orthoclase crystals and the acid plagioclase solutions, which came up after the orthoclase crystallization.

Regardless of theory the fact remains that, apart from supplying food for thought or grist for the mills of controversy, theories afford no help in solving the long-standing puzzle of how to find rich deposits of mica. A geologist is in no better position than an upperchella worker in the spotting of a good mine.

The achievements of geology, so far as mica-bearing pegmatites are concerned, have been so little that, except as "clue finders," people equipped with the science of geology cannot find a place in the industry. In any case they cannot function as professional "puzzle solvers," because the necessary clues to the solution of puzzling circumstances concerning mica are still missing. The geologist is not to blame for this. He cannot possibly be expected to find what is probably not there.

It can be said that enough attention has not been devoted to reduce the problems peculiar to the prospecting of mica to a single formula or set of formulae that would equip the geologist adequately to solve the intricacies of nature. All theories that we have to date have been evolved by authorities visiting the mica fields for only short periods. The solution needs the continued and constant devotion of research scholars, in the true sense of the term, over a long period, perhaps more than a generation. This project should only be undertaken either by the state or by the industry as a whole, not by individual concerns, in view of the fact that the mica trade is smaller than other important mining industries.

Until research is instituted and bears fruit, we must be content to leave prospecting to be done on a basis of a rough empiricism. Those who for some reason or other like to believe we should depend on the scientific method to the exclusion of the upperchella worker are referred to the views of Mr. T. G. Trevor regarding gold prospecting, which reads as follows: *

> It is often thought that the field geologist and the educated mining engineer will take the place of the uneducated prospector of the past. One might as

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* *Transactions of the Institution of Mining and Metallurgy,* Vol. 37, p. 110, 1929.

> well expect the agricultural expert to take the place of the ploughman. In the initial stage of actually finding a payable deposit, trained mining engineers and geologists are far too expensive for the job and quite unsuited to it; in the second or later stage of a mine they save an enormous amount of waste and unjustified expenditure.

These words refer to gold prospecting, where the scientist is on surer ground than he can claim in the mining of mica. One can imagine the larger element of risk and uncertainty involved in the prospecting of mica. Whether one looks at it from a standpoint of theory or of practical experience, it must be agreed that in mica mining lies the truth of the saying, "Nothing succeeds like success." If this cynicism is offensive, the very great place which luck has must be recognized. One's efforts do help but only to the extent where "fortune favours the brave."

To believe that the science of geology can guide the prospector unerringly to the quarry is to cling to a dangerous illusion.

MICA MINING LEASES

Before proceeding with the subject of leases a short discussion on the classification of mica-bearing lands from a legal point of view is essential.

In Bihar, there are mica-bearing lands belonging to

1. Government.
2. Zamindars and tenure holders.
3. Zamindars under Encumbered or Ward Estates.

The areas belonging to the government are called *Khas Mahal* lands. In order to take out a lease in these areas a certificate of approval granted by the government of Bihar is necessary. A major portion of the *Khas Mahal* mica-bearing lands are situated in the Kodarma Reserve Forest and are divided into blocks (squares) measuring 40 acres in area, and 1 square is the minimum leased on this government land.

The amount of rent, Rs.1/0/0 per acre per year in 1903, has advanced gradually to Rs.12/- per acre per year since 1940. To take out a lease, application must be made to the Revenue Secretary, Government of Bihar, Patna, through the Deputy Commissioner, Hazaribagh. The application when submitted to the deputy commissioner for the grant of mica mining leases is first examined by the deputy commissioner on its merits and, if approved, is sent to the commissioner of Chota Nagpur Division Ranchi, who in turn sends it to the Board of Revenue with his recommendations for approval by the board. After approval by the board it is returned to the deputy commissioner, who informs the applicant accordingly. The whole procedure ordinarily takes about 3 months.

Since the mining rules and mineral forms are too extensive to quote in this book, I refer the reader to the Bihar government publication, "Manual, Wastelands and Mineral Concessions, Bihar and Orissa," * for details. However, following are some of the important terms of lease, which might interest the reader.

The Secretary of State hereby grants and demises unto the lessees all those mines, beds, veins and seams of mica (hereinafter and in the said schedule referred to as the "said mineral") situated, lying, and being in or under the lands which are referred to in Part I of said schedule, together with the liberties, powers, and privileges to be exercised or enjoyed in connection therewith which are mentioned in Part II of the said schedule, subject to the restrictions and conditions as to the exercise and enjoyment of such liberties, powers, and privileges which are mentioned in Part III of the said schedule, except and reserving out of this demise unto the Secretary of State and liberties, powers, and privileges mentioned in Part IV of the said schedule, to hold the premises hereby granted and demised unto the lessees from ——— for the term of thirty years thence next ensuing, yielding and paying therefore unto the Secretary of State the rents mentioned in Part V of the said schedule.

3. *Except as provided in Part II no timber to be cut without sanction of collector.* Save as provided in clause 8 of Part II of this schedule, the lessees shall not without the express sanction of the deputy commissioner cut down or injure any timber or trees on said lands, but may, except in protected forests, without such sanction clear away any brushwood or undergrowth which interfere with any operations authorized by these presents.

Part VII

13. *Restriction in assignment or transfer.* The lessees shall not assign this lease or transfer any interest hereunder without the previous written sanction of the local government; nor shall the lessees allow this lease or any interest

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* Superintendent, Government Printing, Patna, Bihar, 1926.

hereunder to be attached or sold in compliance with any decree or of a Court or Revenue Officer.

Provided that in case of any such assignment or transfer as aforesaid (authorized or sanctioned by or under this provision), the instrument thereof shall within three calendar months from the date of its completion be produced to the collector and the sum of Rs.50/– paid to the collector as the fee for registration thereof in his office.*

14. *Not to be financed or controlled by a trust, syndicate, corporation, firm or person.* The lessees shall not enter into or make any arrangement, compact, or understanding whereby the lessees will or may be directly or indirectly financed or by or under which the lessees' operations or undertaking will or may be carried on directly or indirectly by or for the benefit of or subject to the control of any trust, syndicate, corporation, firm, or person unless with the written sanction given prior to such arrangement, compact, or understanding being entered into or made of the local government, and any or every such arrangement, compact, or understanding as aforesaid (entered into or made with such sanction as aforesaid) shall only be entered into or made and shall always be subject to an express condition binding upon the other party or parties thereto that, on the occasion of a state of emergency of which the Governor General of India in Council shall be the sole judge, and it shall be terminable if so required in writing by the local government and shall in the event of any such requisition being made be forthwith thereafter by the lessees accordingly.

Part VIII

2. *To renew.* If the lessees shall be desirous of taking a renewed lease of the premises hereby demised for a further term of 30 years from the expiration of the said terms hereby granted and of such desire shall prior to the ex-

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* This particular clause was amended in 1947. "The lessee shall not assign this lease or transfer any interest hereunder without the previous written sanction of the Provincial Government; nor shall the lessee/lessees allow this lease or any interest hereunder to be attached or sold in compliance with any decree or order of a Court or Revenue Officer; provided that, in case of any such assignment or transfer as aforesaid (authorized or sanctioned by or under this provision), the instrument thereof shall within three calendar months from the date of its completion be produced to the Deputy Commissioner/Collector and a sum equivalent to 25 per cent of the purchase money paid to the Deputy Commissioner/Collector by the transferee as the fee for registration thereof in his office; provided that the purchase money to be taken into consideration in fixing the percentage should be the price of the mines only, and not the price of the building and roads, etc., which may have been constructed by the lessee/lessees."

piration of such last-mentioned term, give to the deputy commissioner six calendar months' previous notice in writing, and shall pay the rents hereby reserved and observe and perform the several covenants and agreements herein contained and on the part of the lessees to be observed and performed up to the expiration of the said term hereby granted, the secretary will, upon the request, and at the expense of the lessees and upon their executing and delivering to the Secretary of State if required a counterpart thereof, execute and deliver to the lessees a renewed lease of the said premises for such one further term of 30 years or such shorter period as the lessees may apply for at such rents as may then be fixed by the local government or, if it is then decided to charge royalty instead of rent, at such rents and royalties as may then be prescribed respectively by the local government or by the Governor General in Council, as the case may be, provided that on whatever terms and conditions the local government may then be granting leases, the lessees shall have the prior right over any other person or persons to take settlement on those terms and conditions.

Part IX

7. *Power to surrender.* The lessees may at any time terminate this lease by giving not less than twelve calendar months' notice in writing to the deputy commissioner and upon the expiration of such notice and provided the lessees shall upon such expiration render and pay all rents, compensation for damage, and other monies which may then be due and payable under these presents to the Secretary of State or any other person or persons and shall deliver up these presents to the deputy commissioner, then this present lease and the said term and the liberties, powers, and privileges hereby granted shall absolutely cease and terminate but without prejudice to any right or remedy of the Secretary of State in respect of any breach of any of the covenants or agreements contained in these presents.

Zamindari lands that are under the Encumbered or Ward Estates are treated as similar to government lands, with a few clauses introduced to suit special conditions. For example, when leasing government lands one is not required to pay any *salami* (consideration money to be paid by lessee at the time the lease is granted). All that one is required to do is to deposit one year's rent as security against the realization of rent. But in the case of lands belonging to Encumbered or Ward Estates, at times one is required to pay a certain amount of *salami,* which is not governed by fixed formula.

For lands belonging to zamindars there is no hard and fast rule with regard to the terms of lease. In each case one has invariably to pay a certain amount of *salami*, from a few rupees to thousands or even lacs of rupees, depending on the richness of the deposit and the bargaining capacity of the lessee. In addition to *salami*, yearly rents are fixed as a rule. In some cases leases have been executed providing for royalty on crude mica with a certain amount of yearly guaranty. Lessees are given the freedom to use the uncultivated land for buildings without paying rent therefor. In case mica veins are found outcropping in a cultivated field, that field may be acquired through private arrangements or through the government by paying a certain amount by way of compensation to the tenant. If it is acquired by a mining lessee, the superior landlord forgoes the rent he collects from the cultivator. Almost always the lessee is given the use, free of charge, of the timber in the area.

As for the period of the lease, there is no hard and fast rule, but, generally, sound parties do not agree to periods of less than 15 or 20 years.

The terms and conditions of lease relating to mica-bearing properties have undergone considerable change since India was declared a republic. The Mineral Concession Rules have also been thoroughly revised, especially with regard to the period of lease, now fixed at 20 years unless the applicant himself asks for a shorter period, and with regard to the maximum allotable area to a single party, which has been fixed at 10 sq. miles. The rates of royalty and dead rent have also undergone some change; for mica they are as follows:

1. Royalty.....	(i) Crude mica	Rs.1/- per maund *
	(ii) Trimmed mica—all qualities other than heavy stained, densely stained, and spotted	Rs.2/8 per maund
	(iii) Trimmed mica other than	
	(iv) Waste and scrap	Rs.0/2/- per maund
2. Dead rent...	Rs.2/- minimum per acre Rs.8/- maximum per acre	

* One maund is equal to 82.625 lb.

CHAPTER 5

Mica Mining

Mica mining begins when a productive pegmatite is discovered and prospected. Prospecting usually involves considerable time and expense and occasionally a rich deposit is found near the surface, but this is an exception.

Unfortunately for mica, confusion still prevails between mining and prospecting, which I have tried to clear up in reference to the working of shallow deposits by small-mine operators. There are several areas in the Bihar mica field, like Deori, Bhurai, Tisri, Telwa (near Simultallah), and Maheswari, that contain shallow deposits. The last-named was recently worked by the Indian government with disappointing results. In the district of Monghry, practically the entire area was extensively prospected by men of adventure with substantial means but without much success.

Activities of the smaller miners are limited mostly to areas that consist of many banded veins, some containing mica in fairly good quantities and others in barely marginal quantities. The redeeming feature of these pegmatites is that the average quality is generally high, although production predominates in the smaller grades. The smaller concerns work these veins under personal supervision with minimum overhead and earn a reasonable profit. Lack of mica concentration in such veins does not justify the heavy overhead of large-scale operations. A margin of 7 to 10 per cent profit is generally enjoyed by small parties for the weekly turnover. There are quite a number of people earning a livelihood from these shallow deposits in the Bihar mica belt. These pegmatites may be compared with the *Suberna Rekha* sand, which contains just sufficient quantity of gold to yield a panner his day's wages.

The working of these veins at shallow depths can hardly be compared with mining in the true sense of the term. To do proper justice to the subject, the shallow workings should be placed in the category of prospecting or at the best exploring. In these cases, it is a common occurrence for the veins to pinch out at depths of about 30 or 60 ft. Such veins generally are short along the strike. In some cases, the deposit along the strike may be developed up to 25 or 30 ft., but commercially speaking, no appreciable importance can be attached to such short strike lengths. These deposits generally have a shallow shaft or an incline, with one or two short levels. In order to avoid confusion, I shall limit my discussion to the working of larger deposits, rich enough to allow more extensive development.

When a pegmatite has proved to contain a commercial concentration of mica, the workings must first be planned and systematized to follow the vein to the zone of regular concentration, if, in prospecting or exploring, the deposit has been irregularly worked (Fig. 15). This may not be necessary where regular concentration is found from the surface, but such cases are rare. Mining operations begin after preliminary systematizing.

Mining of mica usually requires simple methods for removing the valuable material from the mineral deposit. In the Indian mica fields opportunities for more knowledge of improved mechanized methods and upgrading of mica miners offer a broad field of endeavor. Where the veins are very flat, the commonest form of pillar-and-stall method is adopted, while in comparatively steeper deposits drift mining is done. Whatever method is followed—and the method depends mainly on the dip of the vein—mica mining as a whole may be described as mining in miniature form, since the extent to which workable quantities of mica are available in the vertical and horizontal directions is usually limited to a few hundred feet. The deepest mine in the Indian mica field has not extended beyond 700 ft. vertically, save in a few exceptional cases. In the strike direction the maximum length exploited so far is said to be about 2,000 ft. But such cases are uncommon. Generally speaking, the extent of a pegmatite that can be called rich has been limited only to about 400 or 500 ft. in both dip and strike directions.

Referring to the methods described as pillar-and-stall and drift mining, it must be said that both methods are practically the same. When applied to flat deposits it is termed "pillar-and-stall" method, and in case of steep deposits it is called "drift" mining.

These methods consist in sinking a vertical shaft or an incline, as the case may be, following the true direction of the dip, and then driving levels at suitable intervals. Several connections are required to be made at reasonable distances between different levels, either by a winze or by a rise, for facilitating ventilation and blocking out pillars or stopes. This is all that is meant by complete systematic mining, and if one can develop a mine in the manner discussed above, he does full justice to himself and the deposit.

The main object of driving levels or drifts is to form a base for blocking out pillars or stopes and to facilitate the removal of debris for mine development along the strike. Instead of putting a horizontal level from the shaft, some people sink an incline at a low angle downward, as shown in Fig. 19. Then the broken rock must be hauled up either by mechanical hoisting or by manual labour. There may be an undesirable accumulation of water in such inclines, and pumping arrangements will then also have to be made. But if levels are driven properly, rail lines can easily be installed to facilitate the movement of loaded tubs or mine cars, which can be pushed to the shaft by a couple of labourers. Driving levels properly reduces mechanical power and labour to the minimum and greater economy is effected in the development of the deposit.

Connections between different levels should be made by a rise or by a winze. In case of steeply inclined deposits, provided they are not soft, preference should be given to rises. If a winze is sunk, debris must be hoisted to the level, but in a rise the broken rock falls to the level and can be loaded into the tubs and hoisted mechanically. Consumption of explosives in rising is less than in winzing. But in cases where the deposit is soft and consists of kaolinized feldspar, it is desirable from the safety point of view to make such connections by winzes. In flat deposits, it matters little whether connections are made by rises or by winzes.

Since it is characteristic of pegmatites to have more than one zone of concentration, extensive crosscutting in a proved mine becomes essential. Suppose one finds concentration of mica at the junction of a hanging-wall schist and feldspar, there is a likelihood of there being a workable concentration of mica at the junctions of quartz and feldspar or at the junction of footwall schist and feldspar. Under such circumstances, it is essential to drive a crosscut at right angles to the direction of strike for obtaining more information on the whole cross section of the pegmatite where one zone is found economically workable.

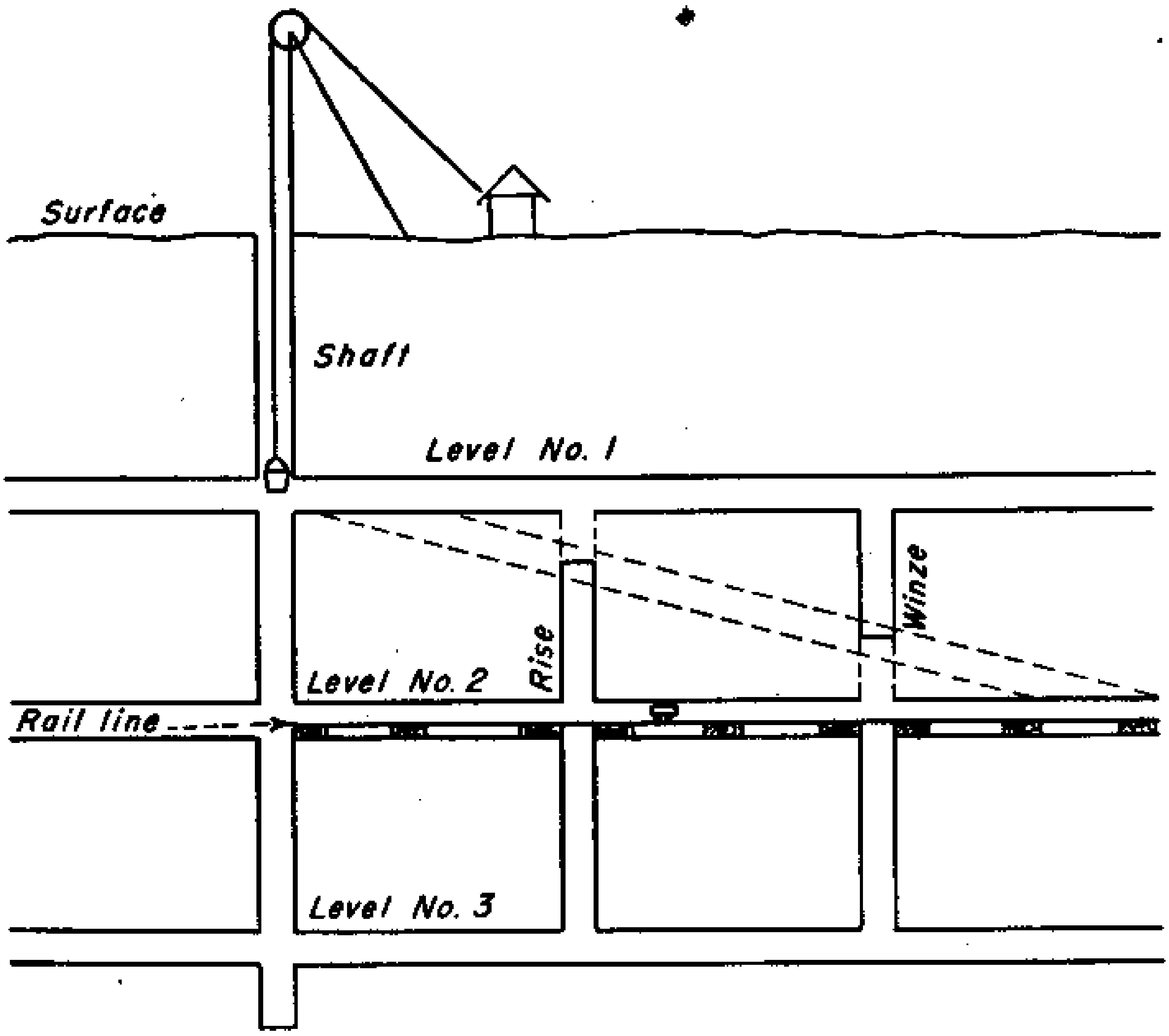

FIG. 19. Vertical projection of a mica mine illustrating winze, rise, drives fitted with rail lines, and trolley, and shaft with hoisting arrangement, and explaining how sinking an incline from vertical shaft in the first level would involve unnecessary hoisting and drainage problems, which can be avoided completely by driving a level.

If the first crosscut produces satisfactory results, the other zone may be developed separately, and several crosscuts at different places may be necessary for making connections between the two zones. But in case the first crosscut meets with disappointing results, the full cross section of the vein should be studied with the help of at least one or two additional crosscuts at different places and depths, before it can be finally assumed that, except for that one zone, the entire mass of pegmatite is barren. This should give a fairly true picture of the whole mass of pegmatite. This practice of exposing the cross section with a view to proving the existence of the parallel zone of concentration is not followed in some cases in Bihar and the owners concerned thus fail to make the most of the deposits at their disposal.

After developing a pegmatite in the manner described, when one reaches the extremity of the vein and finds it pinching out in both horizontal and vertical directions, it is essential to do some reasonable amount of dead work to ascertain the existence of other lenses. This has been discussed in Chap. 2. It is only after one is satisfied, to a reasonable extent, about the absence of any other lens either in the strike direction or in the direction of the dip, that stoping of mica mines should begin from the lowest level.

In most cases, overhand stoping with backfilling is done as shown in Fig. 20, for the most peculiar feature that singles out mica from other mineral deposits is that the valuable mineral can be separated from its associates by simple hand picking, whereas the remainder of the blasted rock is left inside the mine to fill up and give support to the caved-out area. Thus more than 90 per cent of the broken material is left behind in the mine and only 10 per cent or even less is hoisted. This makes the whole operation very simple and economical. Sometimes little pumping is required, so that the cost of bailing out water is at a minimum. In many instances pumping or bailing is not required.

Placing and pointing of drill holes during development presents difficulty in Indian mica mines, since skilled labour is rarely available. As a consequence the use of explosives does not produce efficient blasting. But in stoping, with more than one free face, the pointing of drill holes becomes very simple. Holes are generally drilled parallel to the second free face at a suitable height from the same. In addition to efficient placing and pointing of drill holes when stoping, the quantity of rock broken per foot of drilling is much larger than in development. Consumption of explosives is also less. In view of these advantages, it is expected that mica mining becomes more profitable when stoping than in the development stage. If a mine is developed with proper intervals between two levels (which should generally vary from 25 to 35 ft.), at least two-thirds of the quantity of mica from a particular vein can be obtained by stoping.

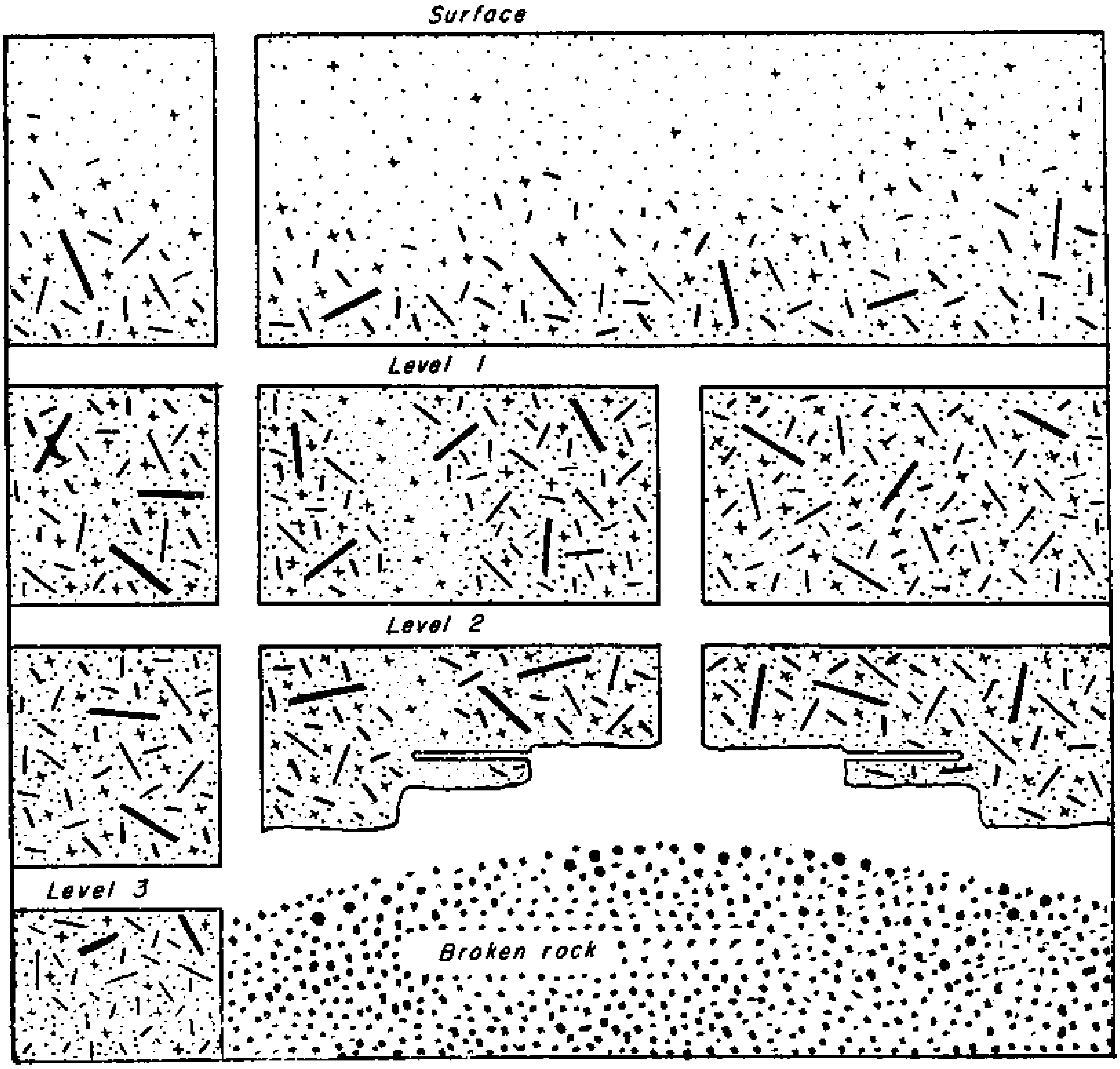

Fig. 20. A vertical projection of a mine showing overhand stoping, beginning at the bottom of the pegmatite once its limit toward the direction of dip is determined. Mica is picked out from the broken associated minerals underground, which mostly amounts to leaving underground 90 per cent of the entire broken rock.

There is, however, one very important factor to be borne in mind in connection with stoping. Since a major portion of the product of blasting is left behind in the mine, mica picking must be done very carefully, since otherwise there is every likelihood of some mica being left behind, never to be recovered. Unnecessary loss of mica through careless sorting can be avoided to a large extent by allowing the blasted rock to fall on corrugated iron sheets placed on the floor of the stope before blasting. When blasting is completed the picking operation is continued. Later the iron sheets are recovered.

To cope with sudden increased market demand for mica, stoping at the time of development can be done and production increased. But from an economical point of view, such untimely stoping should be avoided as much as possible, for in such instance timbering of the mined-out area becomes essential and adds to the ultimate cost of production. In flat deposits, it is not so difficult and expensive to stope out certain portions of the mine when the development work is going on in the deeper sections. But in the case of very steep deposits or vertical deposits, stoping during development presents considerable difficulty and it is more expensive to provide protection to the stoped-out areas. Stoping should always be done after a deposit has been fully developed and its extremities determined. Though the operations described appear simple and easy, mica mining has its own problems, peculiar to its own techniques, which demand sensible solutions for efficient operations.

The amount of mechanization and technical competence required for an efficient and economic operation of a mica mine is described in the following paragraphs.

BLAST HOLE DRILLING OF MICA-BEARING ROCK

The first problem is breaking the rock and separating the mica from its associates. This problem varies directly with the hardness of the deposit, and the entire operation becomes very slow without mechanization.

A mine can, no doubt, be developed quite systematically with hand drilling; but the progress in such case is never more than 25 per cent or at the best 30 per cent of what can be had with compressed-air drilling. Moreover, the present-day high labour wages (which are at least 200 per cent more than the pre-war wages) have made the working of a mine with hand drilling uneconomical.

There is, however, one very important point to be borne in mind with regard to the efficiency of compressed-air drilling, which is completely dependent on proper placing and pointing of holes. Without a fair knowledge of both the theory and practice of drilling and blasting one cannot possibly operate a mine with compressed air with reasonable efficiency. As a matter of fact, if the holes are not pointed and placed properly on a development face, the entire operation may even result in a complete failure, causing a total loss of explosives and energy spent in drilling the holes.

The theory of drilling and blasting is generally understood by all qualified mining engineers, but this aspect of mining has been unfortunately ignored by most people in the Indian mica fields. Until recently, with the exception of a few concerns, all operations in the Bihar mica field depended on hand drilling. Those who did practice pneumatic rock drilling devoted little attention to the adoption of modern methods of drilling. This is attributable to the lack of proper knowledge of its advantages. It should be clearly understood that mica mines, unlike other metal and nonmetallic deposits, offer some difficulties for any systematic method of accurate and efficient drilling. Knowledge of even the elementary principles of drilling would be helpful in achieving efficient results, in any case.

Referring to Fig. 21, suppose a hole is drilled from the side of a winze in a pillar in the direction of *ab*, and *c* is the center of the explosive cartridge inside the hole. Now the line *cd* drawn from the center of the cartridge is perpendicular to the cartridge and is called the "line of burden." The line *cd′* drawn from *c* is perpendicular to the nearest free face, which in this case is the roof of the lower level and also of the second free face (the first face being the side of the winze from which the hole is drilled), and is called the "line of least resistance."

The line of least resistance makes an angle ϕ with the line of burden. The efficiency of the charge of explosive is inversely proportional to this angle, or, in other words, the best efficiency of explosive is obtained when the angle becomes zero. This is possible only in the case of stoping, when there are always two free faces (hole *ab′*). But, in the case of a development face, only one free face being available, the efficiency of blasting practically falls to zero when the angle becomes one of 90°—when, for example, a vertical hole is drilled from the bottom of a winze (see Fig. 22). Such a failure of blasting is called a "blown out shot."

Now in this particular case, there being only one free face, the line of least resistance passes through the center of the hole and the line of burden makes an angle of 90° with the line of least resistance and runs straight to the solid portion of the surrounding rock. When the cartridge explodes, the tremendous volume of gas while trying to expand blows out the tamping in the hole and escapes, and the entire operation is a failure. Therefore, it is essential to reduce the angle by drilling holes that make a slight acute angle with the horizontal axis. For efficient operation, the magnitude of the angle depends on the length and spacing done between a pair of holes. One hole, or even a pair of holes, is never sufficient for breaking a development face. A number of holes comprising a full round must be drilled and blasted in sequences, as shown in Fig. 23.

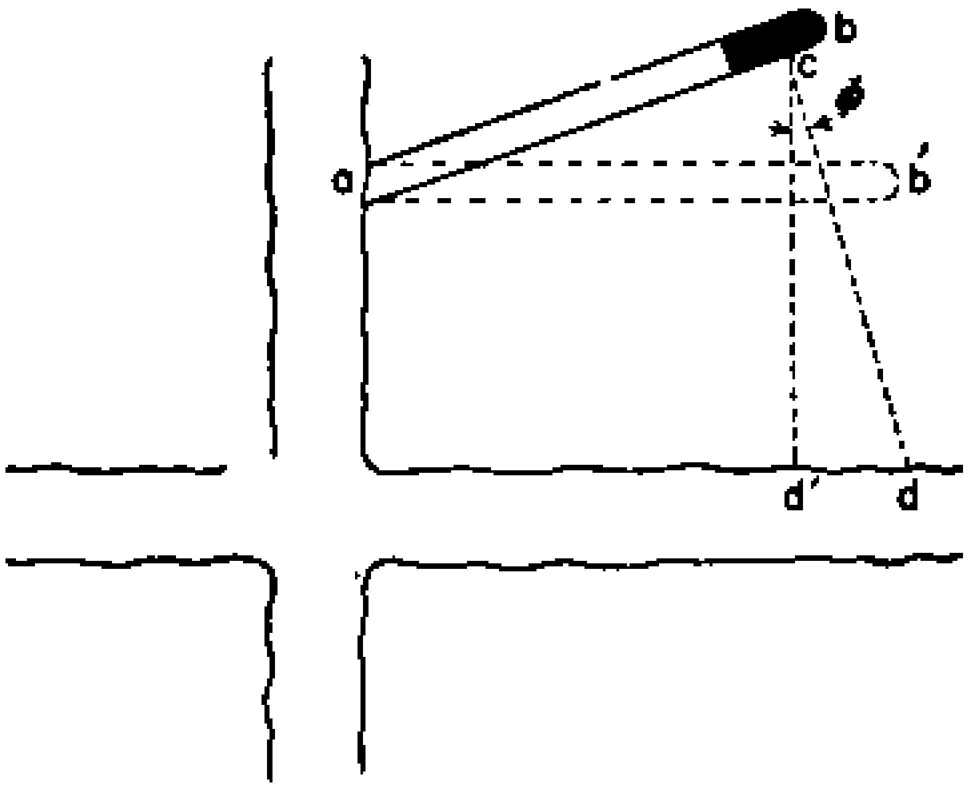

Fig. 21. Sketch explaining the theory of drilling and blasting; *cd* is line of burden, and *cd'* is line of least resistance.

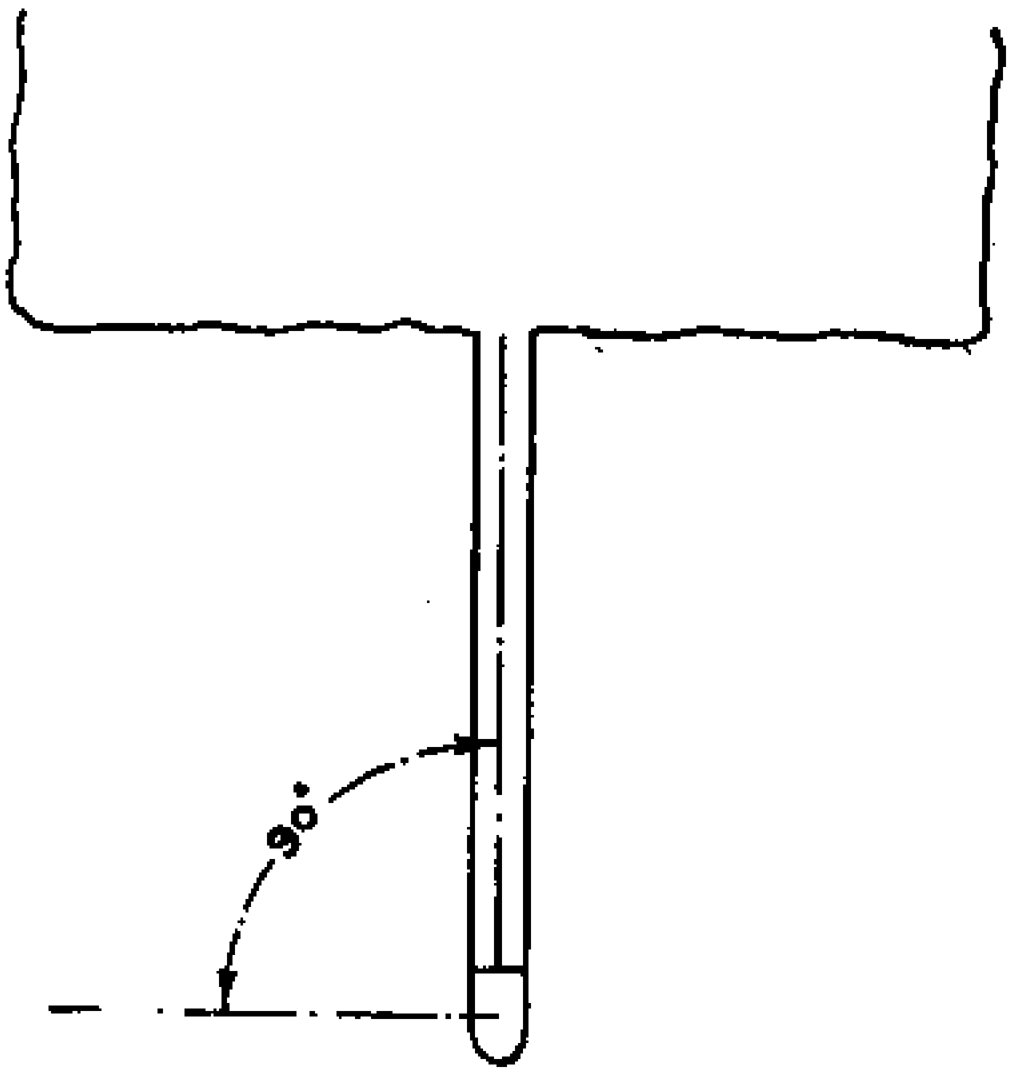

Fig. 22. A wrong method of drilling a blast hole in a winze. Even with tamping, the maximum explosive effect is never obtained in a vertical hole.

Economically speaking, the correct pointing and placing of holes in a round ultimately determines the efficiency of the entire operation. However, to afford a clearer understanding of this subject, let us discuss a complete round for a particular type of rock.

For example, in the first round, four pairs of holes are drilled and blasted at a time. These holes are commonly known as "cutters," each being of equal length and drilled at an angle with the horizontal axis, as shown in Fig. 24, which represents a horizontal section of the drive along the line *ab* in Fig. 23. In other words, each pair of holes is drilled at such equal angles as would prevent them from crossing each other or meeting at their extremities but would keep them only a few inches apart at the end on the same horizon. Drilling of these holes is really the most difficult part of the entire operation. After a successful blasting of this round, a sort of V cut is produced in the center of the drive, creating two faces on either side, as shown in Fig. 25. The next round is then drilled, consisting of the same number of holes as before. These holes are known as "easers" and are drilled at slightly wider angles than the cutters. After these easers are blasted the face assumes the form shown in the Fig. 26, and whatever is left on the sides is taken out by blasting another round of holes, known as "dressers," which make an angle of more than 90° with the horizontal axis of the face, as shown also in Fig. 26. To level up and straighten the drive, holes are drilled at a slight angle and blasted both at the top and

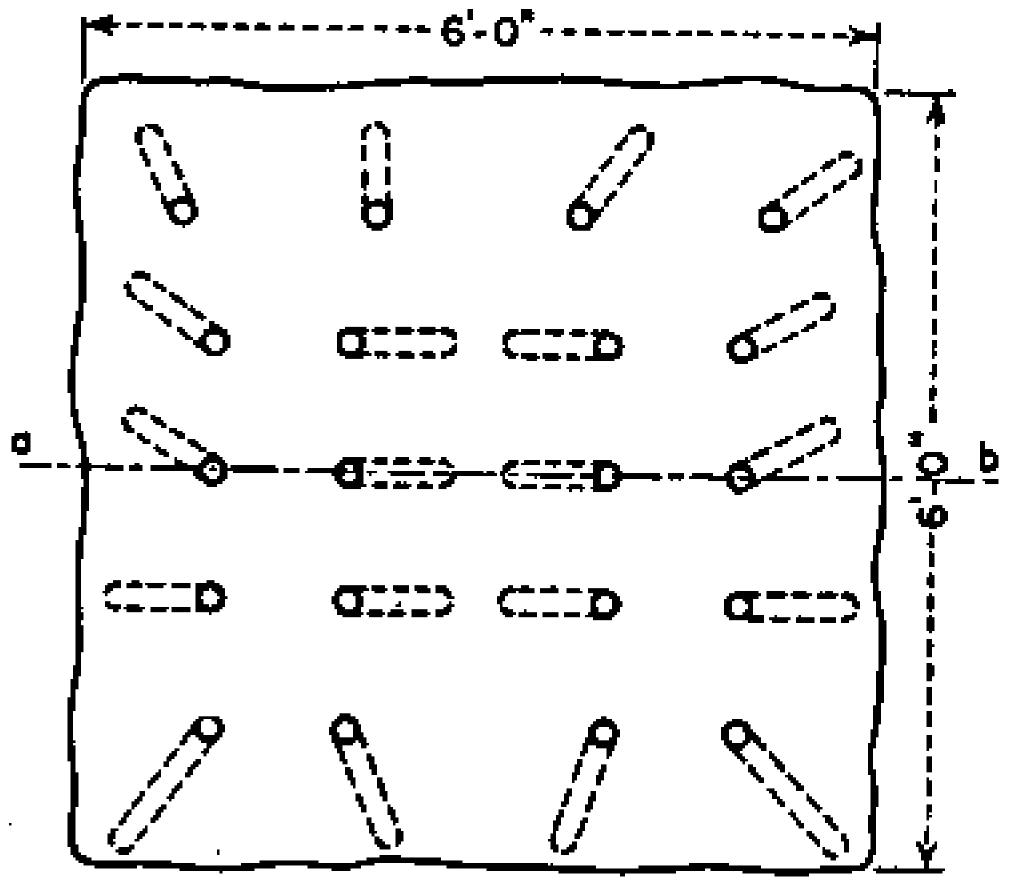

FIG. 23. Arrangement used in Indian mica mines of holes for drilling a round in fairly hard pegmatite.

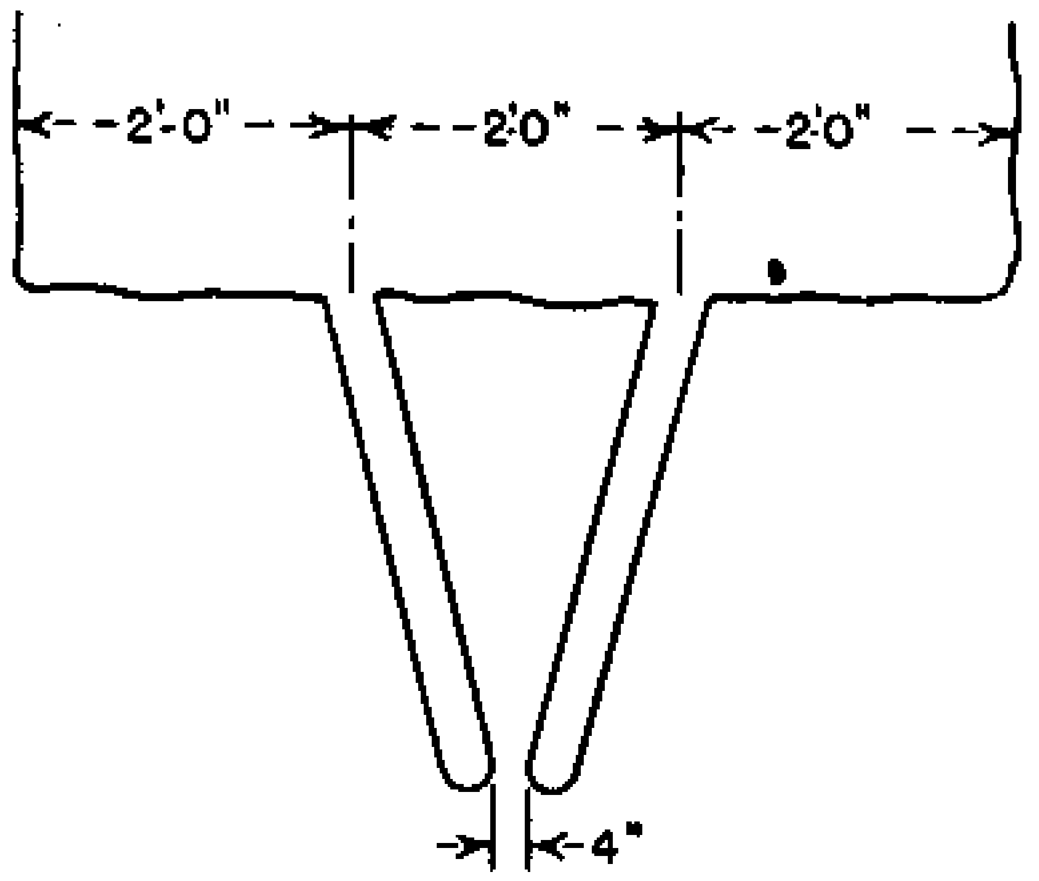

FIG. 24. Sketch of plan arrangement of the cutter holes driven in a face.

the bottom, as shown in Fig. 27. These holes are known as "tops" and "bottoms."

This is just a typical case. Drilling rounds may be modified and the number of holes per round may be increased or decreased in a number of ways, depending on various local conditions. An important point to remember in planning a round of holes is that the spotting and pointing of holes should be made as simple as possible, even at the cost of some efficiency, because the person who lays out the drilling method will not be there to put it into practice. The

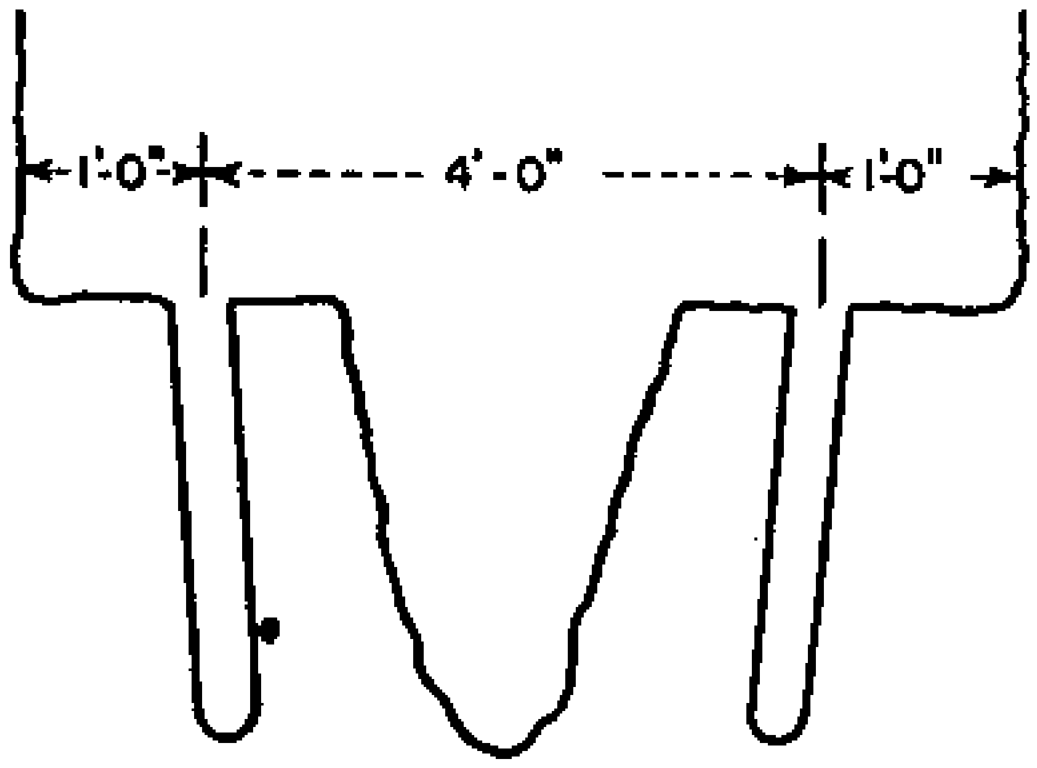

Fig. 25. Appearance of the face in plan after cutter holes are blasted. Two side holes are also shown.

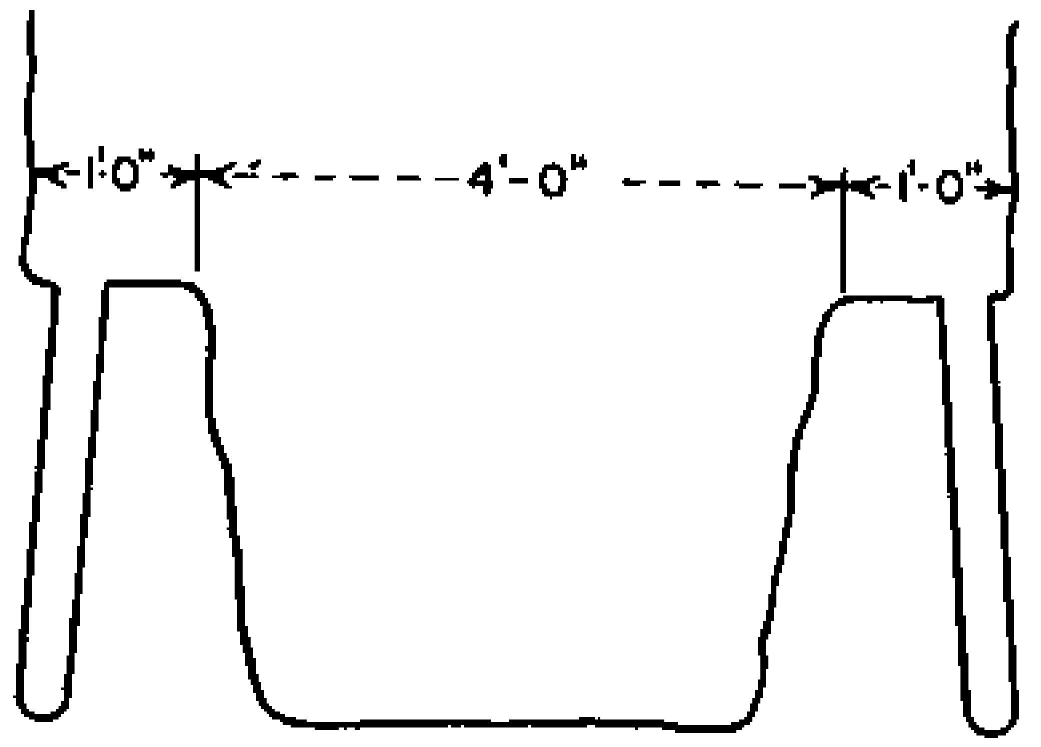

Fig. 26. Arrangement in plan of so-called "dresser" holes at the sides of the face.

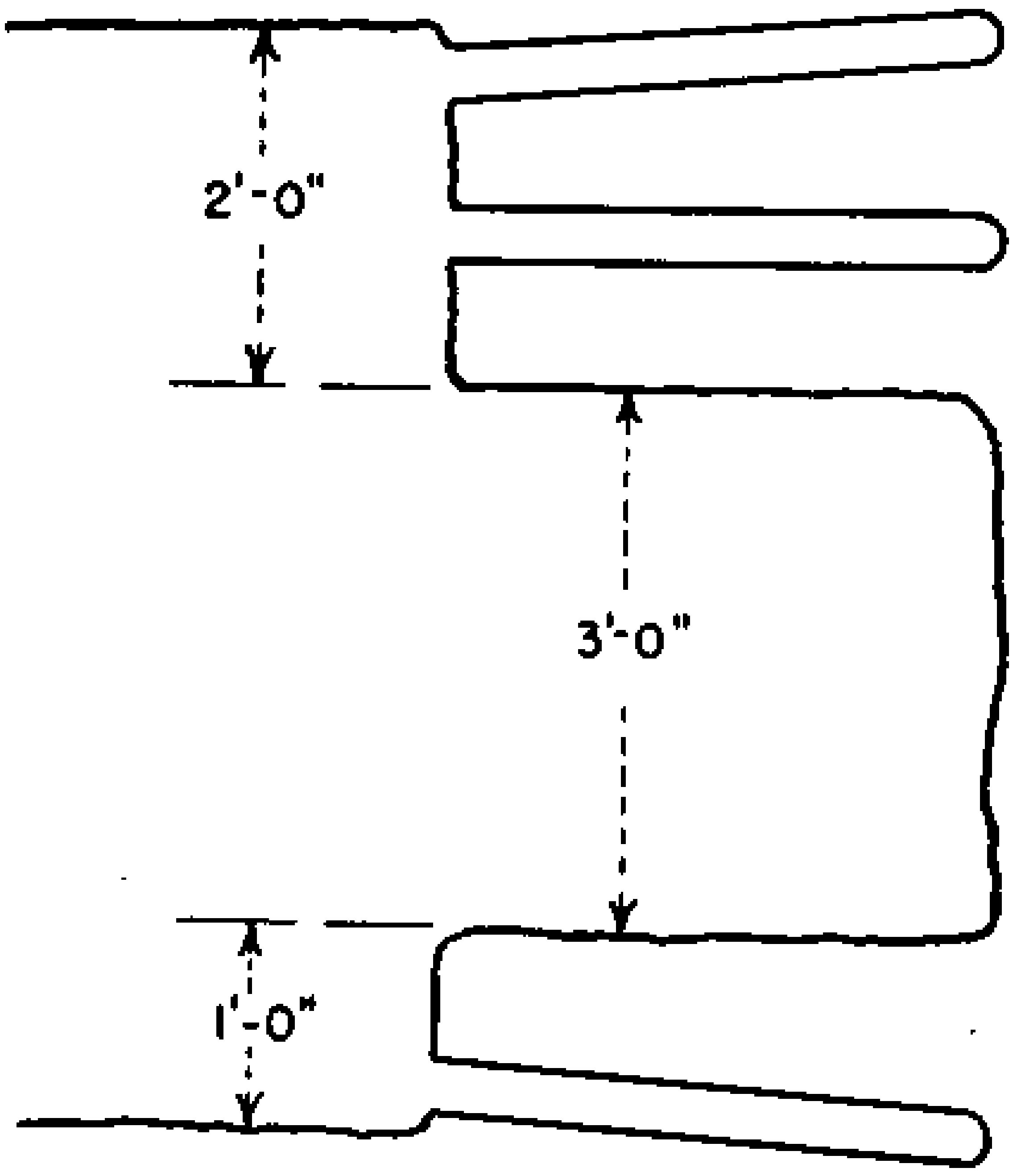

Fig. 27. Projection of face showing position of "top" and "bottom" drill holes.

entire operation is usually carried out by inexperienced labourers. In our search for a better method, we should bear in mind, that, whatever improvement a new method offers, it may lead to failure if the labourers are unable to follow the method closely in all essential details. One might take issue to the typical case cited above as being wasteful because of an unusually large number of holes in a round. But a large number of holes are required only in exceptional cases, where the zone of concentration predominates mostly in massive feldspar and small-size mica. In an average mine, a drift section of 6 by 6 ft. can be cleared with 15 to 20 holes. In exceptional cases, a set of eight to ten holes have been found to be sufficient to clear such a face. Factors such as the area of the working face, hardness of the rock, and other rock conditions visible to experienced eyes determine the maximum depth and the minimum number of holes to be drilled for the successful blasting of a round. The occurrence of mica in the pegmatites in the form of books of various sizes and thicknesses, in a most irregular manner, does not permit the drilling of holes deeper than 2½ to 3 ft., owing to the danger of damaging the books by the drill bits, as shown in Fig. 28.

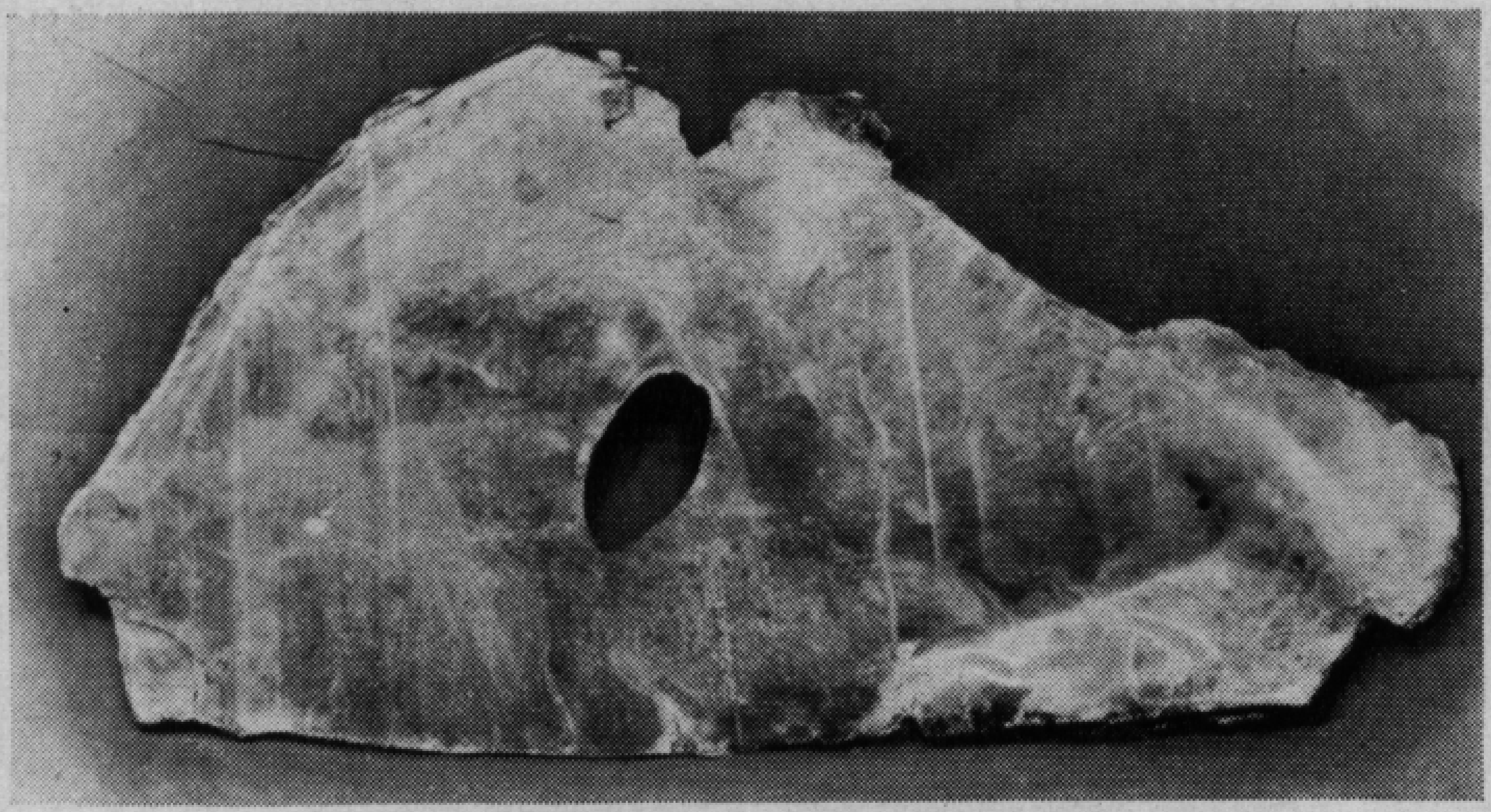

Fig. 28. Photograph showing a mica book having been damaged by a drill hole.

Moreover, the presence of small pieces of mica in the deposits offers obstacles to drilling. If the bit contacts a large book of mica and the drill operator tries to go through it, progress becomes extremely slow. If it meets the surface of the book, drilling is difficult though not impossible. But if the bit touches the edge of a book and tries to make its way across parallel to the cleavage plane, as shown in Fig. 29, the bit gets jammed and further progress is virtually impossible. In view of the foregoing, an attempt to drill longer holes on a productive face has been found to be uneconomical. Hence, in a complete round, the number of drill holes in a mica mine is greater than in other mines.

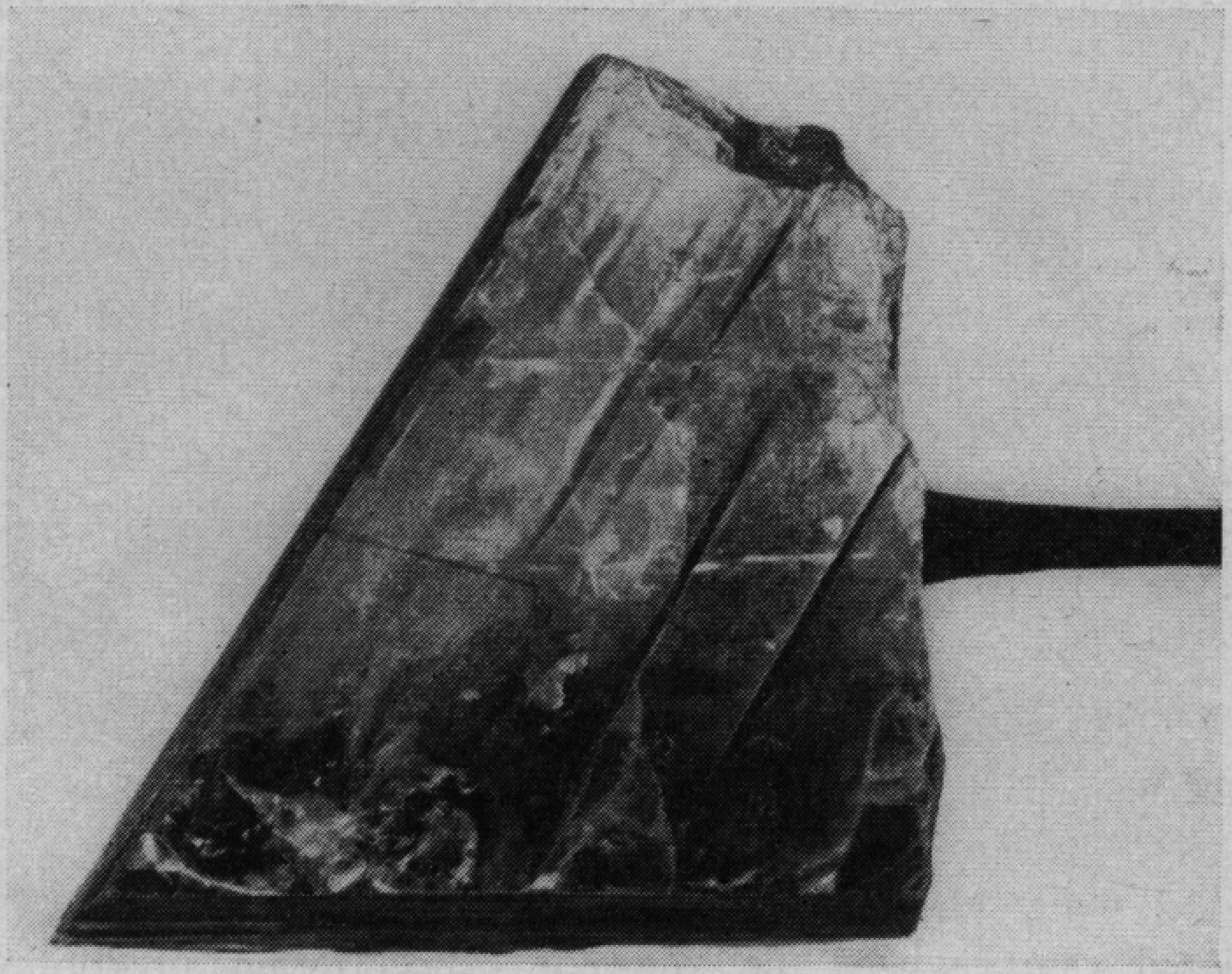

FIG. 29. Photograph showing a drill bit touching the edge of a mica book and trying to make its way across the book parallel to its cleavage plane.

The practice of drilling and blasting a complete round in several installments also may appear to waste time and energy. This, too, is unavoidable. It is impossible to see through the vein and place holes in a manner that would not damage the mica books. As a result of blasting, all the mica books do not fall down. Portions of the larger books remain sticking to the face even after blasting, and they must be recovered by hand chipping. After blasting a set of six or eight holes and recovering all the books in the manner aforesaid, it is possible to get a better picture of the face in deeper sections. The portions of books that become exposed after such blastings and cannot be recovered by hand chipping offer a much better line-up for placing the holes in the next round. Care must be used to avoid any damage to the books by drilling. Though it wastes time and expense, the completion of a round in several installments is indispensable in mica mining.

Considering the question of quantity of explosives needed in each hole for successful blasting, the entire subject is dependent on trial-and-error methods. A categorical statement cannot be made about this subject. This much can be said for the case discussed above, that since the first round of cutter holes must share a larger burden for creating a second free face on the development face, the quantity of explosive required in such holes is naturally larger than that for the successive shots.

Generally speaking, the amount of explosive required to be charged per hole is directly proportional to the hardness of the rock, the angle ϕ, as well as the length of the holes, which ultimately determines the burden on such holes. However, a reasonably correct estimate of such charges can be made only by persons who have adequate practical experience in this particular line, since the different types of rocks have a wide range of variation in hardness. Generally, explosives such as dynamite or gelignite are used in the mica mines of Bihar.

Compressors and Rock Drills in Mica Mines

In established mines, stationary air compressors driven by diesel engines are found most economical. Such units can be used only in mines that on the basis of available evidence can be expected to last for at least three to four years. After having proved a vein, a man of experience can very well judge this aspect with a reasonable amount of certainty. For a concern working comparatively small deposits or a number of both large and small mines, it is always desirable to have a few portable air-compressor units (Fig. 30). This avoids installation charges, which are always necessary for a stationary compressor unit. Besides, the installation of a stationary plant takes at least a couple of months, or even more if bricks have to be made on the spot, and an exploring pit or even a small mine cannot afford to wait that long. These workings warrant the use of portable machinery, which can be put to service with the minimum difficulty and maximum speed. Installation costs for stationary plants would be large for such short-lived and/or uncertain deposits. For a concern working a number of mines, these portable plants are of immense help, almost indispensable, especially for speedy exploration of a promising vein before the installation of a stationary plant can be recommended. In pre-war days, a complete stationary plant (both engine and compressor) capable of compressing about 200 cu. ft. of air would cost about Rs.10,000/–, whereas a portable compressor of the same capacity would cost about Rs.12,000/–.

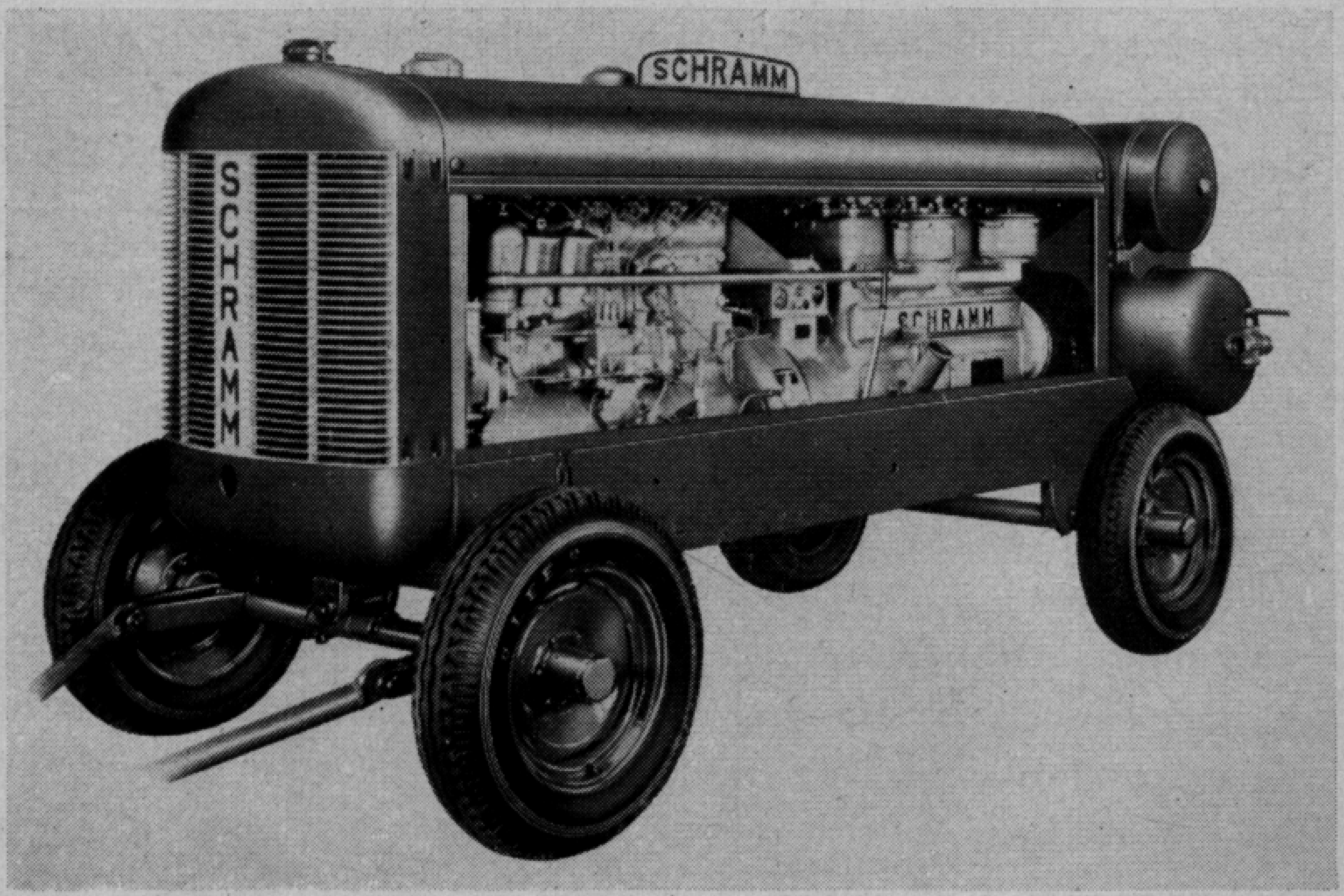

Fig. 30. A portable air-compressor plant, very common in mica mines. (Source: Schramm, Inc., West Chester, Pennsylvania.)

Among rock drills, 45- to 50-lb. jackhammer drills (Fig. 30*A*) have so far been found most serviceable. The pre-war cost of these drills was about Rs.600/– to Rs.700/– each. Shanking and sharpening of the drill bits is generally done by hand in the mica field, but in places where comparatively larger size compressed-air plants are installed, sharpening and shanking should be done by mechanical sharpeners driven by compressed air. This increases the efficiency of drilling to an appreciable extent and effects a considerable saving of drill steel as well. Frequent breaking of pistons (a very expensive part of a rock drill) is caused by hand shanking. This can be avoided by mechanical shanking. Sharpeners could be purchased in the pre-war days for about Rs.2,500/–. In addition to the increased speed in drilling, another important feature of compressed-air drilling is that the exhaust air from the machine improves mine ventilation at practically no cost.

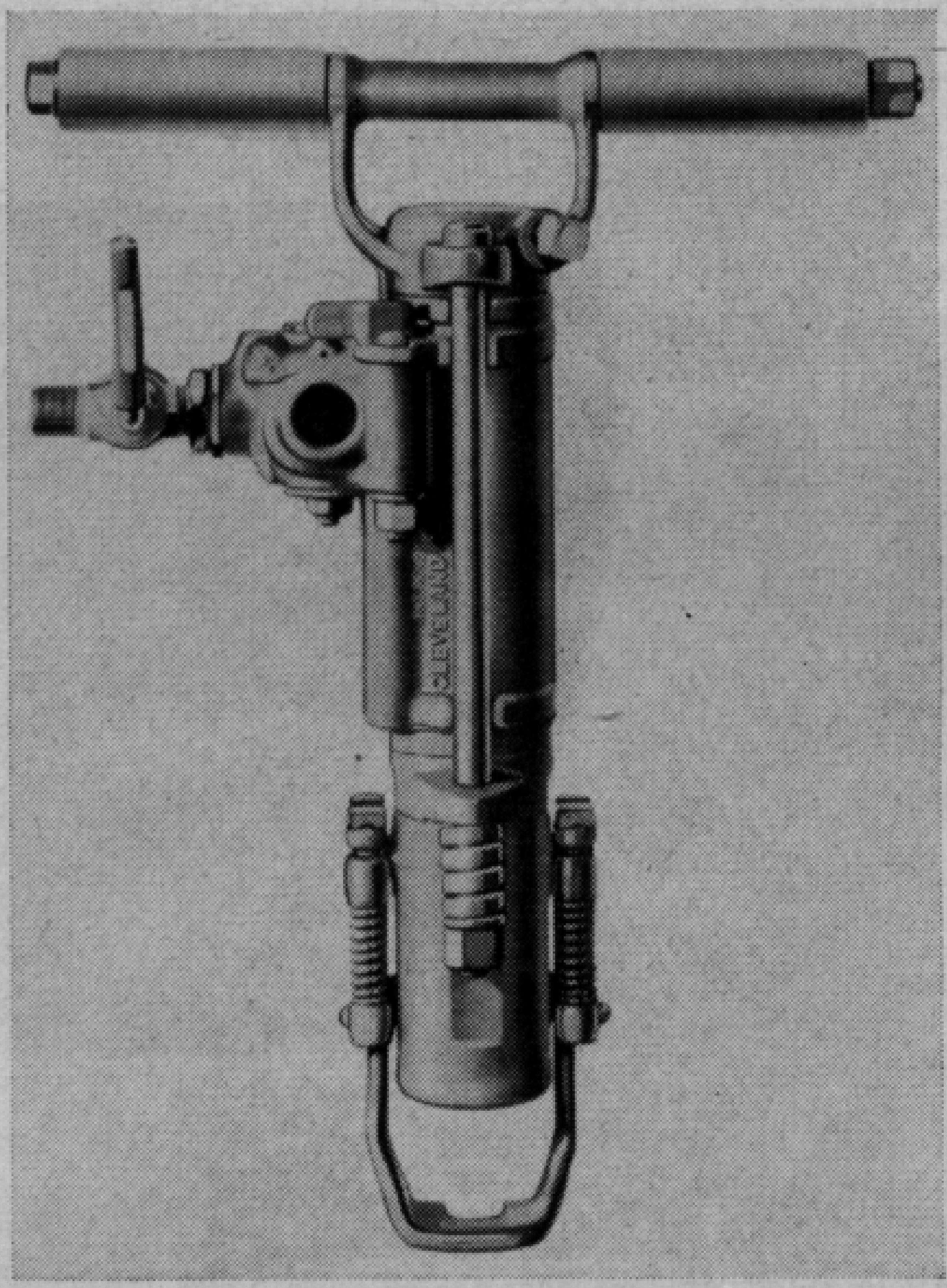

FIG. 30*A*. A lightweight jackhammer drill.

Careless pipe fitting of the air line (both the main line and the branches) results in an undesirable leakage of air, which lowers drilling efficiency, which in some cases becomes very serious. The extent of these losses is often not realized by the *mistri* or fitter staff or even by the supervisors because the leakage of compressed air, instead of being uncomfortable for the workers, as in the case of steam, makes the mine atmosphere more pleasant. This is one of the main reasons for carelessness on the part of the staff.

Hoisting and Handling Materials Underground

Consideration must now be given to the removal of the blasted material in the development face before further advance can be made. It is practically impossible to remove and hoist all the broken material produced by compressed-air drilling with manual labour. Even when a mine is operated by hand drilling, the installation of a mechanical hoist becomes essential after a certain stage.

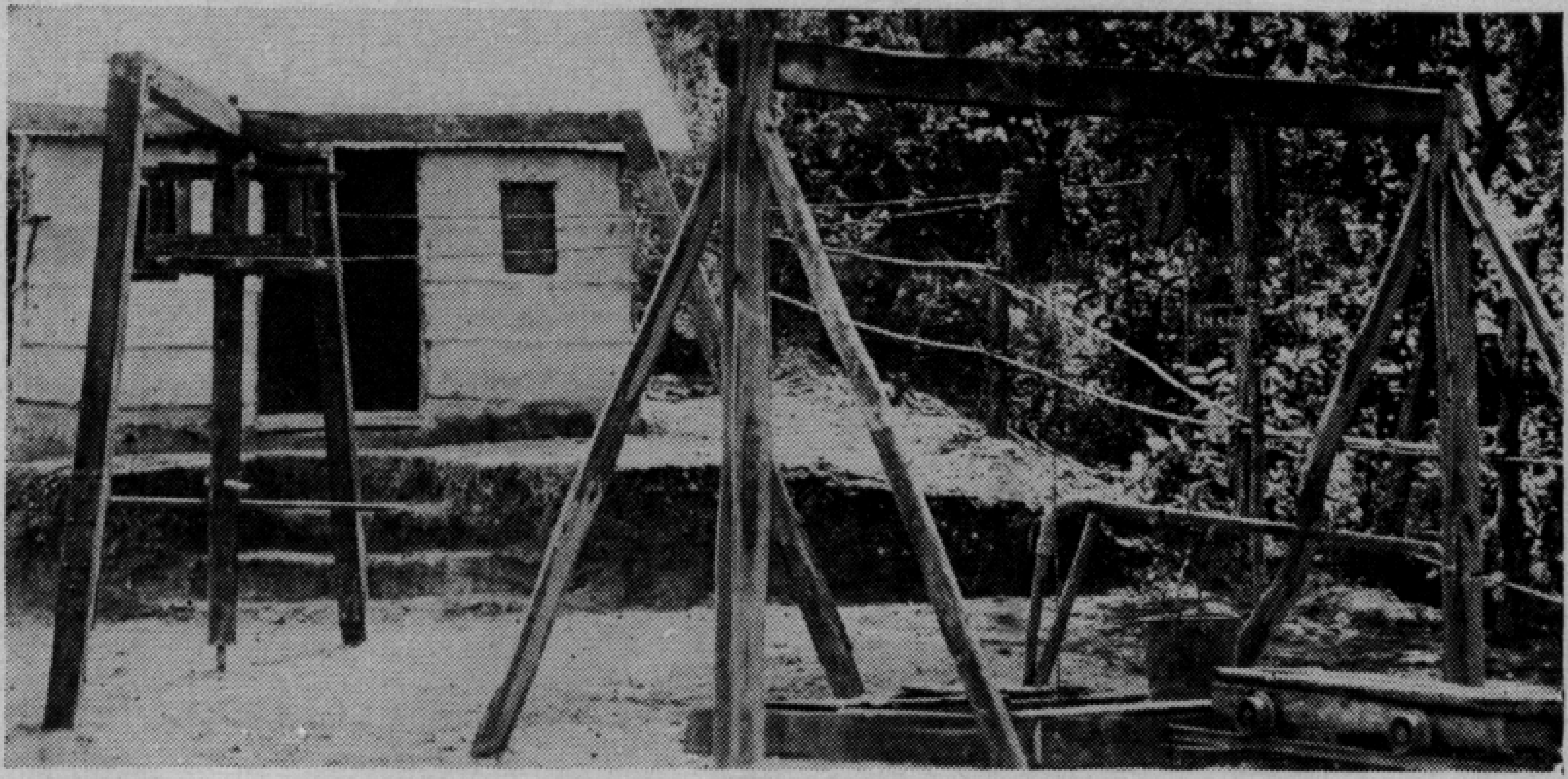

Fig. 31. A manually operated hand whim used in Indian mica mines for hoisting from shallow shafts.

The number of working faces increases as the mine becomes larger and the problem of removing the waste rock more difficult, warranting the installation of mechanical haulage. If the work of clearing debris is left to manual labour alone, the number of labourers required increases with development, and as a consequence the cost of removing a unit quantity of broken material increases from day to day and labour becomes a paramount factor. If there is a shortage of labour supply, production obviously suffers. Time being a very important factor in the industrial world, clearing the debris from the deep mines, even assuming adequate labour supply, is a very slow process.

The labour factor may be eliminated to an appreciable extent by installing a crab winch or a locally made wooden winch operated by manual labour. But such hand-operated hoisting devices have a very limited capacity. Moreover, their capacity is inversely proportional to the depth. These devices are found useful for prospecting pits or for clearing debris from a shallow working like a winze. When larger quantities of broken materials are involved, one must plan more expeditious hoisting arrangements. For a medium-size mine, where the expected hoisting per day does not exceed 20 or 25 tons a day, a hand-operated "whim," as shown in Fig. 31, has been found very useful, especially for hoisting from a vertical shaft. None of these devices is of any appreciable use for a big mine, where the expected hoisting is 40 or 50 tons a day, and the installation of a power-driven hoist becomes essential. Normally, one hoist is sufficient for a fairly large mine, but since the pegmatites are traversed by an extensive system of folding in the direction of both dip and strike, it becomes essential at times to have secondary hoisting arrangements underground. For example, Fig. 32 represents a vertical cross section of the main dip of a mine that has folded, changing the dip to 40°, after having run practically vertical for about 150 ft.

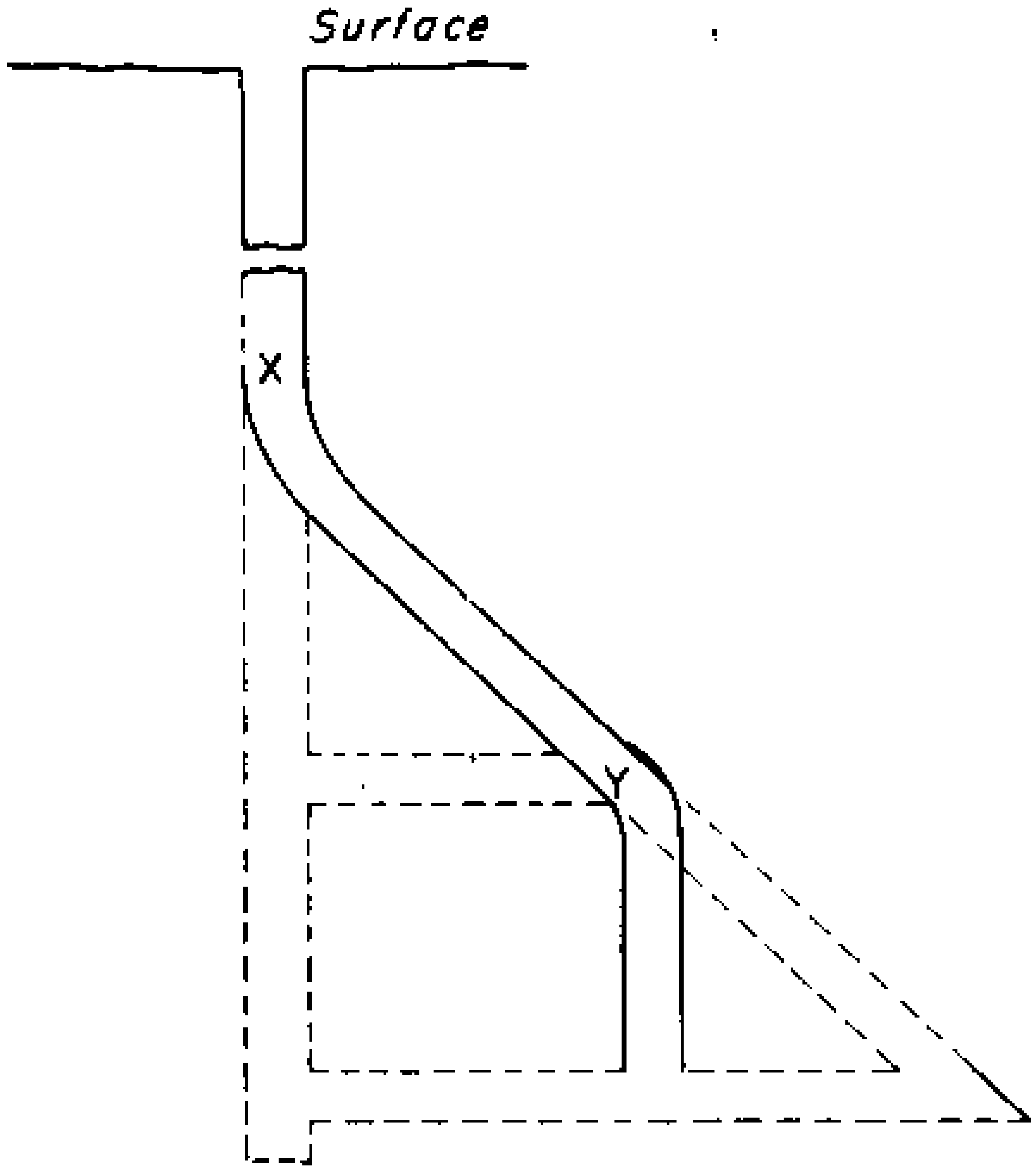

FIG. 32. A sketch showing how folds occurring in pegmatites sometimes require changing the direction of sinking on vertical shaft to an incline, necessitating arrangements for secondary winding. In case folds are at two places, *X* and *Y*, the workers continue the shaft and enter the vein by crosscutting.

This change in the angle of the dip makes it impossible for a hoisting shaft to handle debris beyond the point *x* (apex of the fold). To solve this problem, one can either install another hoist at the top of an incline on the same level at a suitable distance from the bottom of the shaft or sink the shaft straight and make connections

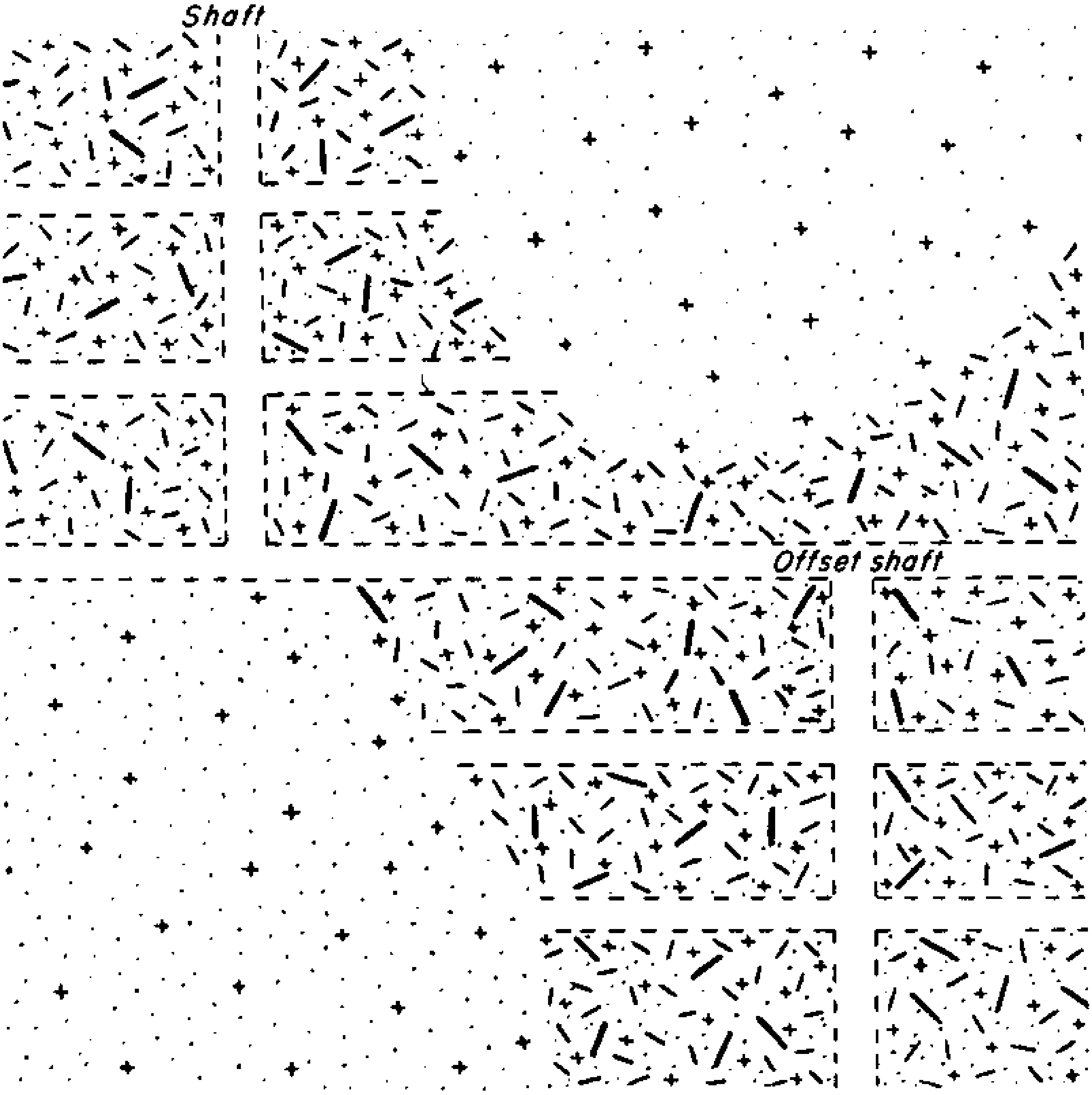

FIG. 33. A sketch showing how shifting of mica concentration sometimes requires sinking of an offset shaft.

with the lower levels by crosscutting. In the latter case, the amount of dead work increases with the depth, as the length of crosscuts increases with the development of the dip. For example, if the gradient is 1 in 2, then for a vertical drop of 20 ft. the length of crosscut will be 40 ft. and for another drop of 20 ft., *i.e.*, total drop of 40 ft., the length of crosscut will be 80 ft. This dead work is most undesirable in mica mines. For *X* amount of useful work done, one must do

1.5X amount of dead work in the first level, about twice as much in the second level, and so on. Apart from its considerable effect on the ultimate cost, progress is hindered considerably because development along the dip must wait till shaft sinking is completed and a crosscut is driven to the point on the lower level to be developed. Broken rock from development along the dip between the upper and lower level must be handled by manual labour. This results in complications and extra work, and progress becomes entirely too slow. In these circumstances, the installation of a second hoist underground becomes the best solution from the standpoint both of low cost and of speedier operation.

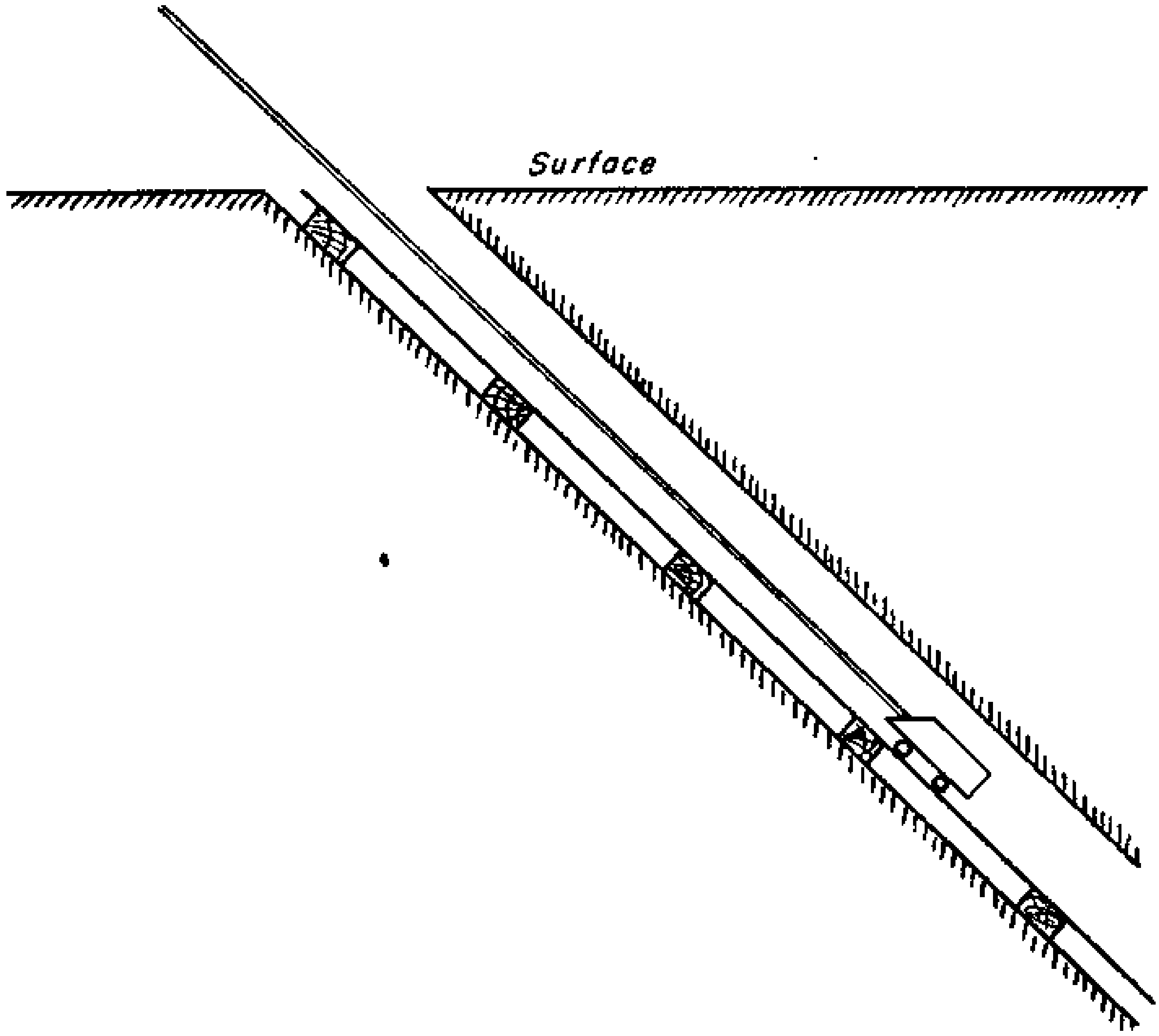

FIG. 34. Cross section of hoisting by skip in an incline shaft.

If instead of one fold there are two as shown in Fig. 32, the shaft must be sunk vertically and connections made between the apex of the second fold and shaft, and the secondary hoist should be placed at this point.

Besides folding, there are other factors requiring the installation of a secondary hoist, such as the shifting of the zone of concentration, as shown in Fig. 33. In such cases, one might suggest sinking a new shaft from the surface, which is not only desirable but essential from the standpoint of safety and ventilation. Before shaft sinking can be completed one must provide a stopgap arrangement for the interim by setting up a secondary hoist, as development must not be stopped because time and other losses would then be incurred. The secondary underground shaft should be so located that the new shaft from the surface may be made coincident with it. For this, an accurate survey of the whole mine is essential.

There are of course deposits of steep dips where some dead work is unavoidable and skips cannot be used. A deposit requiring an incline shaft and skip as shown in Fig. 34 offers satisfactory operating conditions. The amount of dead work to be done in steep deposits is much less than in flat deposits, as shown in Fig. 35.

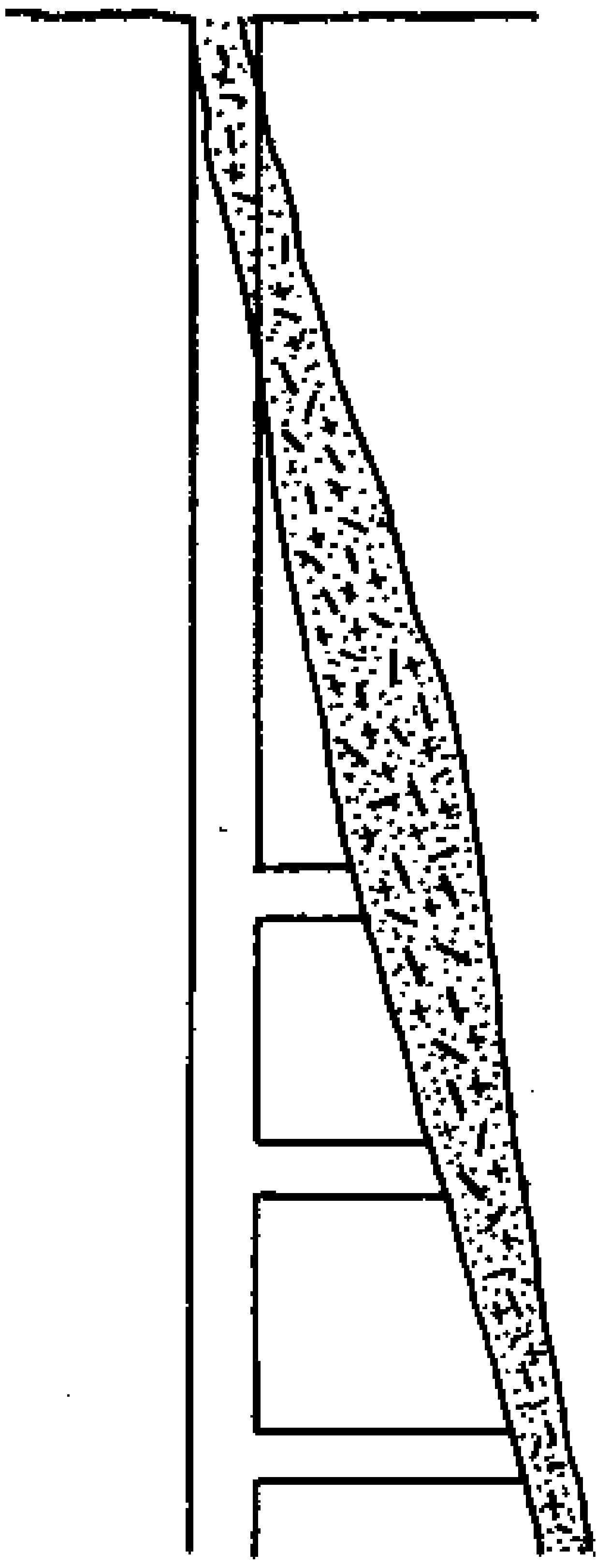

FIG. 35. Cross section of a vertical shaft and crosscuts driven to a mica-bearing pegmatite having a very steep angle of dip.

If the shaft is not sunk to its proposed depth and a connection is not made with the vein on the lower level, proper development of the mine in depth suffers. At times, for want of sufficient labour, most people in the mica field cannot resist the temptation to work the vein along the dip. This poor planning retards the proper development of the mine, and the operators become guilty of being "penny wise and pound foolish."

Even in the biggest mine we have today in the mica field, the hoisting per day during three shifts does not exceed 50 to 60 tons. Small hoists of 5 to 7 b.hp. are sufficient for the work. The largest hoist that has so far been used is 10 b.hp. The type found most suitable is the double-cylinder, single-drum, reversing-type diagonal hoist, by Holman Brothers, Ltd. (Fig. 36). The smallest size of the above hoist is 5 b.hp. and is generally used in mines of average size. These could be bought before the war for

Rs.1,500/–. In bigger mines, the next larger size hoist is used, which was obtainable at Rs.2,000/– before the war.

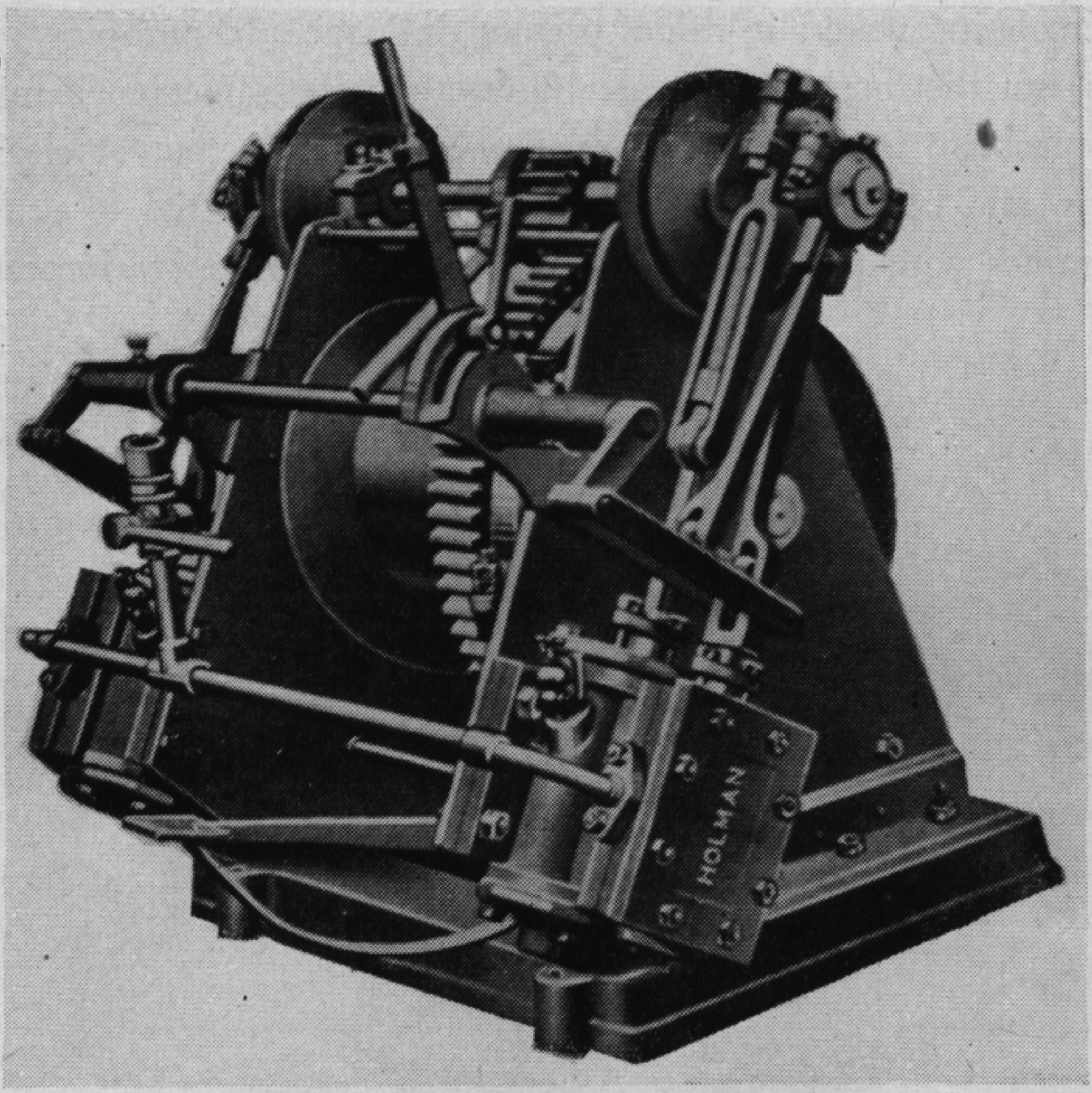

FIG. 36. A 10-hp. double-cylinder steam hoist (product of Holman Bros., England).

Detailed specifications of the Holman Brothers, Ltd., hoist are as follows:

	WF	*WG*	*WH*
Cylinder bore and stroke.....	4 by 5½ in.	5 by 7 in.	6 by 8 in.
Drum capacity, 800 wire rope.	800 ft. of ⅜ in.	1,760 ft. of 7/16 in.	2,100 ft. of ½ in.
Rope pulls..................	1,320 lb.	1,950 lb.	3,120 lb.
Length......................	3 ft. 5 in.	4 ft. 4 in.	5 ft. 4 in.
Width.......................	3 ft. 2 in.	4 ft. 1 in.	4 ft. 10 in.
Height......................	2 ft. 10 in.	3 ft. 6 in.	4 ft. 1 in.
Net weight..................	980 lb.	2,000 lb.	3,000 lb.
Horsepower..................	5	7	10

Pumping and Drainage

Percolating waters in mines present drainage and pumping problems, but the intensity of water flow is not the same in all mines. The problem is more or less similar in nature to that of clearing debris, and beyond a certain limit it becomes essential to provide the mines with power-driven pumps. In mica mines reciprocating pumps, which can be run both by steam and compressed air, have been found the most useful. Tangye's "special" steam pumps (as shown in Fig. 37) or duplex-piston type of steam pumps, capable of pumping 1,200 to 1,400 gal. of water per hour, are generally used in mines of average size. In some cases it may be necessary to install pumps of larger capacity, up to 4,000 to 5,000 gal. per hour. These pumps can be operated with compressed air or steam with equal efficiency.

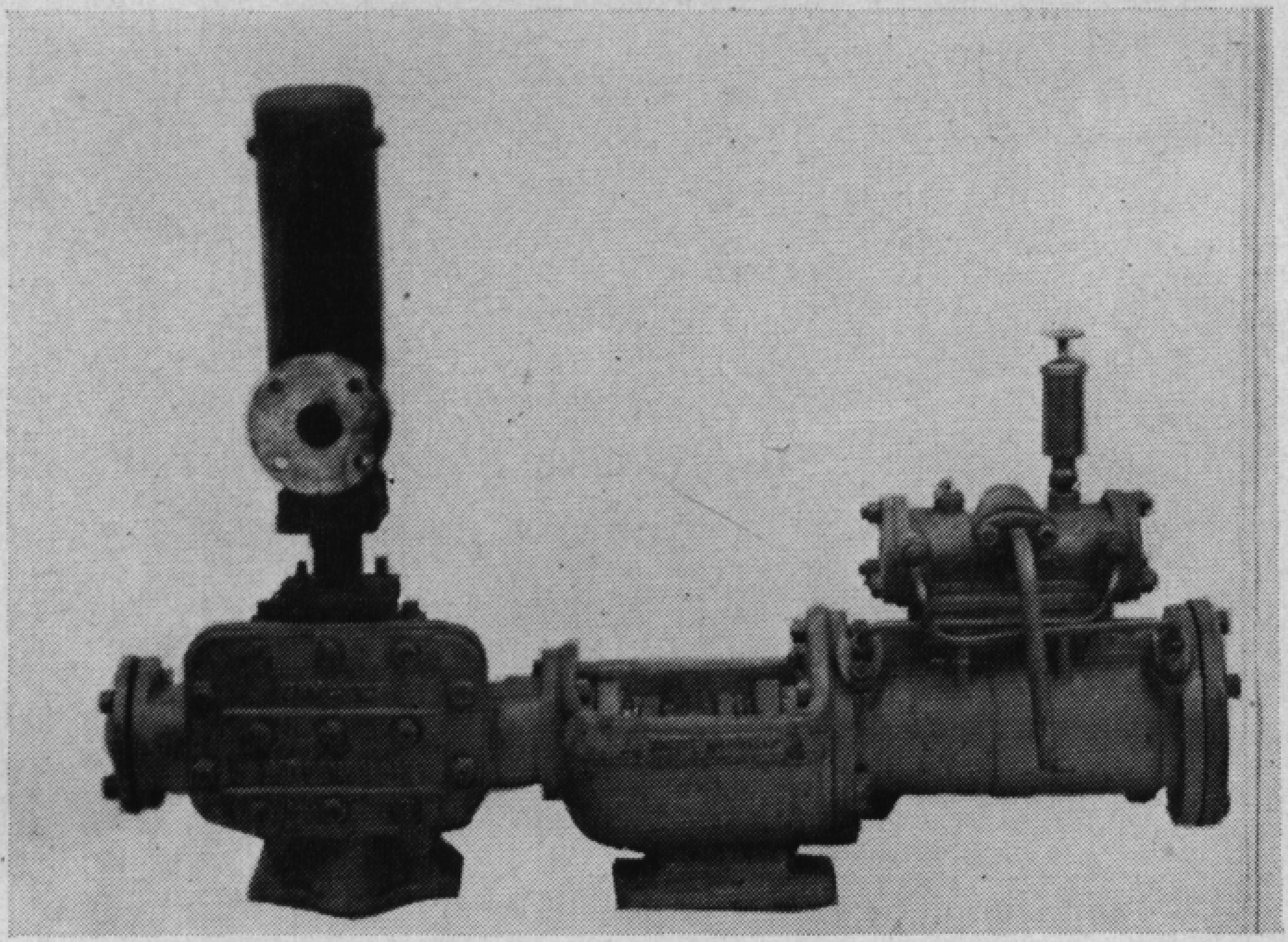

Fig. 37. A reciprocating Tangye's special pump for mine drainage.

The following are the manufacturer's specification for Tangye's special steam pumps, 300-ft. series.

Diameter of steam cylinder	5 in.	6 in.	6 in.	8 in.
Diameter of steam pump	2½ in.	3 in.	4 in.	4 in.
Length of stroke	12 in.	12 in.	12 in.	12 in.
Water per hour, approximately	1,270 gal.	1,830 gal.	3,260 gal.	3,260 gal.
Diameter of suction inlet	2 in.	2½ in.	3 in.	3 in.
Diameter of delivery outlet	2 in.	2½ in.	3 in.	3 in.
Diameter of steam inlet	¾ in.	¾ in.	¾ in.	1 in.
Diameter of exhaust outlet	1 in.	1 in.	1 in.	1¼ in.
"Head," ft. per lb. steam pressure	5.7 lb.	5.8 lb.	3.2 lb.	6 lb.
Approximate weight	4 cwt.	5 cwt.	6½ cwt.	8¼ cwt.
Price	Rs.510/-	Rs.580/-	Rs.680/-	Rs.825/-

When mining is done in more than one part of the deepest section, two-stage pumping usually becomes necessary. Water is first pumped up to a sump at a higher level, where another pump of larger capacity is installed to pump the water out of the mine, as shown in Fig. 38.

An important point to remember is that pipe lines should be laid in as straight a manner as possible. Unnecessary bending of these lines should be avoided because the efficiency of pumping decreases considerably with the increase in the number of bends.

If pumping and hoisting are done with steam, the entire length of steam pipe should be insulated with a thick coating (at least 1 in. thick) of mud and mica-scrap mixture to prevent condensation of steam, which seriously affects efficiency. The insulating of steam pipes has not been adopted in all mines. Such negligence is probably due to lack of knowledge of the considerable efficiency that is lost by lack of insulation.

These are the three main problems required to be met for mechanization of mica mines. To estimate the total cost of mechanizing a mica mine of an average size, let us sum up the cost of the various pieces of machinery discussed above. In addition to these mechanical units, other pieces of equipment necessary are a boiler, pipes of different sizes with fittings, steel rope for the haulage engine, rail lines, tubs, etc. For the sake of calculation, we can assume

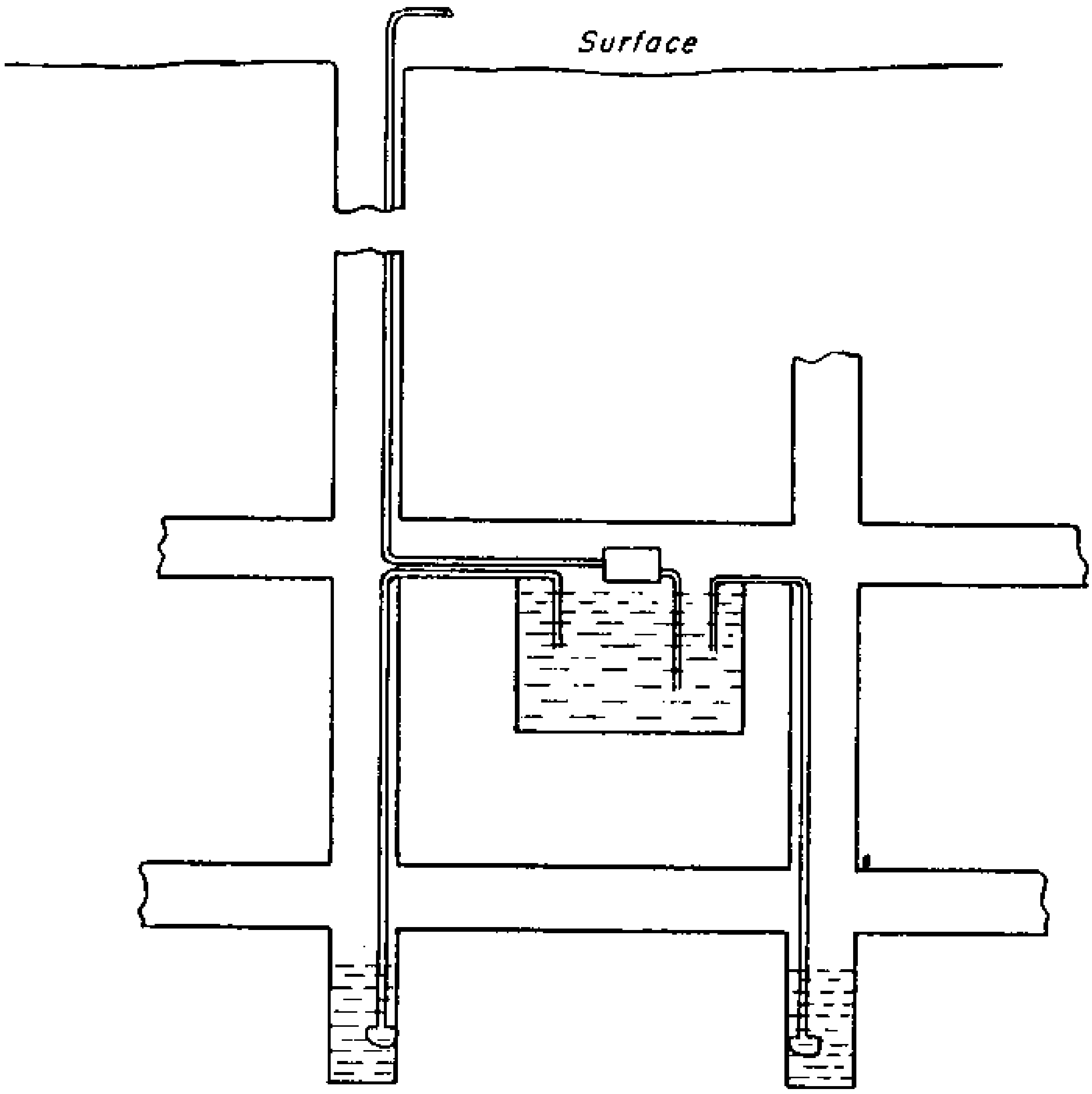

Fig. 38. A sketch showing two-stage pumping systems.

the following equipment and costs will be required for a mine of average size:

One boiler of 10 to 12 b.hp.	Rs.4,000/–	
Two Tangye's "special" pumps, 2½ by 5	Rs. 510/–	each
One duplex pump, 7½ by 5 by 6	Rs.1,100/–	
One diagonal hoist, 5 b.hp.	Rs.1,500/–	
500 ft. of ½-in. steel rope	Rs. 250/–	
1,000 ft. of 1-in. and 2-in. galvanized pipes with fittings	Rs.1,000/–	
1,000 ft. of rail lines with fittings	Rs.1,000/–	
Two tippling tubs (mine cars)	Rs. 300/–	each
Two buckets	Rs. 75/–	each

According to the estimate above, Rs.10,000/– (approximately $3,300) to Rs.11,000/– was necessary for thoroughly mechanizing a mine of average size in the pre-war days. If rapid progress and larger production are desired, the necessity for having a compressed-air plant arises and it is necessary to invest an additional sum of about Rs.15,000/- to Rs.20,000/- at the best, as detailed below:

One compressed-air unit capable of compressing about 200 cu. ft. of air per minute	Rs.13,000/-
1,000 ft. of 1-in., 2-in., and 3-in. pipes with fittings	Rs. 1,500/-
Three hammer drills complete with hose and pipes at Rs.650/- each	Rs. 1,950/-
Tools, repair parts, and other accessories	Rs. 3,500/-

In all, about Rs.30,000/- are required to mechanize completely a mine of average size, including the use of compressed air. It is needless to mention that as the mine develops deeper than 300 to 400 ft., additional finances may be needed for supplementary purchases of pipe and rail lines, etc. But even in exceptional cases, the total cost did not exceed Rs.50,000/- to Rs.60,000/- prior to World War II. Since present conditions are abnormally uncertain in regard to the availability of mining machinery and equipment at reasonable prices, not even an approximate estimate can be made at this time. It is certain, however, that it is now more than double what it was before the war.

TIMBERING

We may now turn to the problems that do not call for mechanization. In a mine where one is confronted with loose deposits, timbering of the shaft and drives, raises and winzes, and the roof of the drifts becomes essential. Local carpenters available in the mica field are experts in this art of timbering. Even where there are very loose deposits, like those predominating in kaolinized feldspar, protection of the underground workings is not beyond the capacity of these carpenters and superior technical knowledge is not required. The simplest methods of timbering are sufficient to cope with whatever problem is found in Indian mica mining. Generally timbers 6 to 8 in. in diameter answer the requirement adequately, and they are locally available in sufficient quantities. This further simplifies the problem of timbering.

VENTILATION

Operation of mica mines without any exception is dependent on natural ventilation. Sometimes in smaller mines the problem of ventilation becomes an acute one, owing chiefly to the absence of a second shaft or other outlet. In some large mines, where extensive development has been done along the dip and strike, ventilation sometimes in deeper working faces becomes very poor, in spite of the presence of two or three shafts. But the problem can easily be solved by installing ventilation doors or stoppings at suitable places to direct the air through practically all the working places before it leaves the mine through the upcast shaft. Figure 39 shows a method of up and downcast mine ventilation.

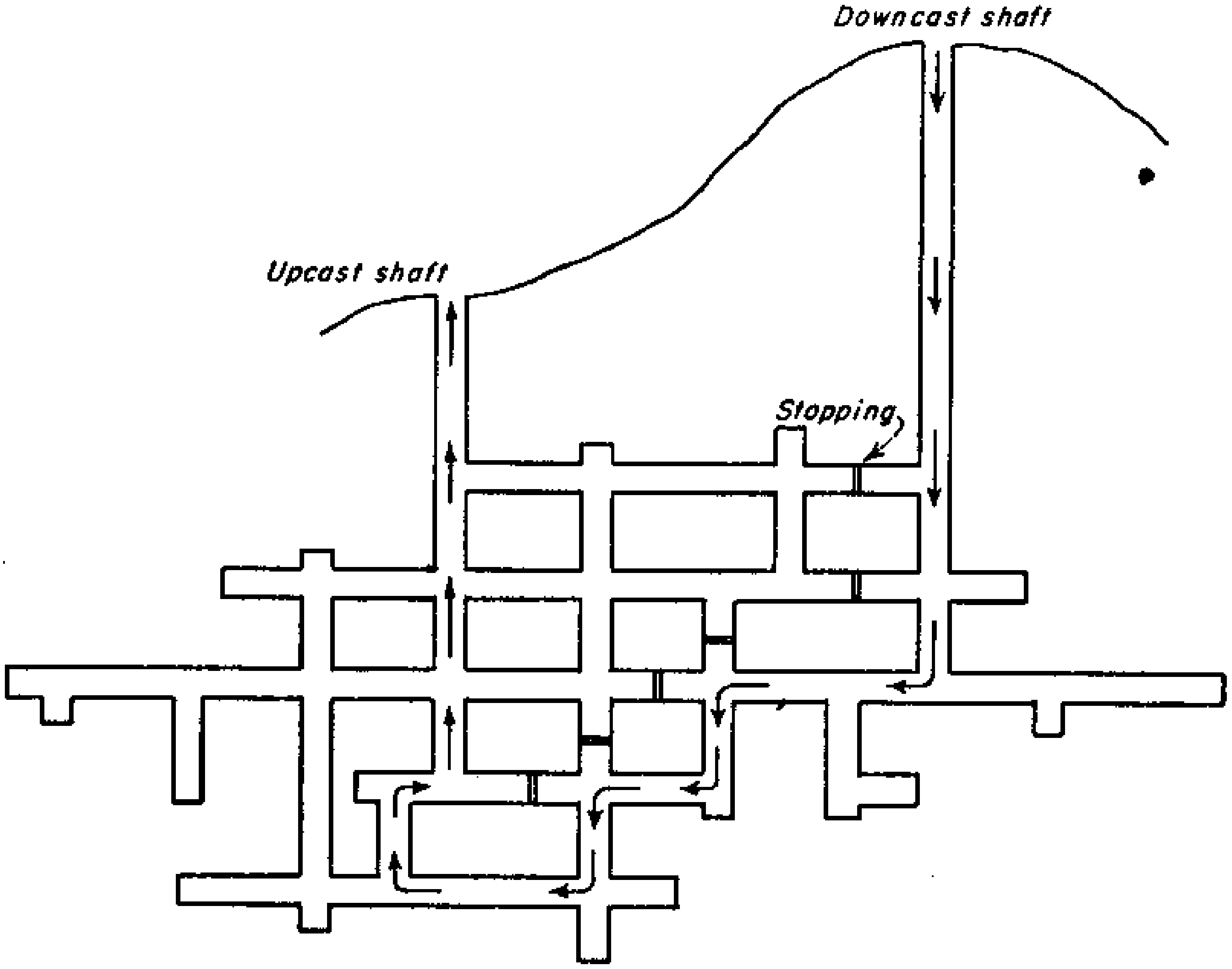

FIG. 39. Ventilation to the lower levels can be obtained by properly placing stoppings or mine-ventilation doors on the various levels.

These are the main problems presented by mica mining, and it can be concluded that the solution of these problems does not at all call for a high degree of mechanization or large-scale financing. The total finance needed by firms operating a number of mines will involve a large sum for mechanization. Special technical knowledge for efficient operation of the largest mine that we have today is not absolutely necessary. In case of compressed-air mining, however, a thorough knowledge of drilling and blasting is essential.

TECHNICAL KNOWLEDGE REQUIRED FOR MICA MINING

The present-day high labour wages on one hand and the mining of mica to greater depths on the other have made the adoption of compressed-air mining absolutely essential, especially from the economic point of view. This method of mining requires the installation of other mechanical equipment such as boilers, pumps, hoists, etc., to handle the larger output of broken material and water from the rapidly advancing development faces. The efficient working of a mine under such conditions calls for technical knowledge.

In being emphatic about the necessity of having a thorough knowledge of drilling and blasting, the author does not intend to give the impression that use of compressed air is extremely difficult and hence should be avoided. The author considers it important that new entrants into the field should be cautioned against disadvantages of injudicious adoption of compressed-air mining.

It is not true that scientific knowledge, to the extent needed in the mining of mica, is difficult to impart to the average man. Use of compressed-air-driven equipment in mining is simple and can be easily taught to a man of average intelligence and ability. Operating the equipment can be learned in a few months.

The most difficult problem is one of management of mica mines and is distinct from the technical aspect. A manager of a mica mine must have a thorough knowledge of the economics of mica mining and technical competence. I wish to emphasize that, in the final analysis, it is the understanding of the economics that ultimately decides the efficiency of the management.

It is a fact that people with theoretical knowledge of a very high order have not proved successful in the mica field. This is true of many other walks of life, where book knowledge and school training alone are found to be bad substitutes for practical experience. It is particularly true of mica mining, for here the school-trained technician tries to introduce unnecessarily elaborate methods without first analyzing all local conditions and knowledge to determine whether new methods are economically practical.

The School of Mines curriculum at Dhanbad (Benares Hindu University), prescribed for mining students, will show how exhaustively subjects such as assaying, sampling, various branches of geology, mechanical engineering, civil engineering, surveying, mechanical drawing, etc., besides the principles of metal mining, are taught by these institutions. Students are trained in three or four years, with attention given mainly to subjects devoted to working of metalliferous deposits. They are trained, as far as possible, to operate different divisions of metal-mining enterprises, such as Mosabani copper mines of Singhbhum, the Kolar Gold Fields of the Mysore State, South India, or Bawdwin Mines of the Burma Corporation, Ltd., Northern Shan States, Upper Burma. Unfortunately no institution pays attention to training students in problems peculiar to the mica-mining industry, such as the different nature and behaviour of the various types of mica-bearing pegmatites, suitable methods of drilling and blasting mica veins, the various operations involved in the processing and manufacturing of mica, etc. This omission may be attributed to a sad lack of informative literature on mica, as well as to the smallness of the industry in comparison to other mining industries, in terms of the annual production and value, even though India does produce more than 75 per cent of the world's mica.

In consideration of the peculiar problems involved in coal mining, it is treated as a special subject and its curriculum does not include many subjects relating to the mining and processing of metals and nonmetallics. Moreover, the diploma course of the Indian School of Mines includes the study of both these branches of mining; and since most students go in for the full diploma course of the Indian School of Mines, the standard of education that they get is so high as to render their employment unduly expensive for the present-day mica-mining industry of Bihar. The present demand for such engineers, especially in Indian coal fields, is so great that today there is an acute shortage of these engineers even for the larger mining industries of India. Besides, almost all the mining centers have become industrial colonies, affording all the amenities and attractions of modern urban life. The scope for rise, which with experience and knowledge such engineers can hope for in these large-scale mining industries, is also very considerable.

But unfortunately for mica, the location of the mines being mostly limited to the deep forest areas of Bihar, it is practically impossible to afford to engineers the amenities and attractions that they can enjoy in other spheres of mining. Nor is it possible for mica to promise an equally bright future prospect. Even if mica miners should venture on the employment of such technicians with their minimum starting pay, mining engineers rarely consider it worth while to adopt mica mining as a permanent professional career.

Recently a few students from the Indian School of Mines were employed in the Bihar mica field; but most of them left the field after getting a second-class colliery managership certificate, and, to be just, one cannot possibly blame them for it. After all, it is natural to look for better prospects.

In its simplicity, mica mining does have a technique of its own and does need technicians. But like coal mining, mica mining should be regarded as having special problems and is a subject for special study. In the absence of any institution dealing with problems of mica mining, the only solution is the formation of mica-mining classes conveniently located in the mica field. With an elementary knowledge of mining as a background and a suitable curriculum for training students in mica mining, it should not take more than a year to train technicians to answer the requirements of the industry.

Students in these special classes should work in the mica mines for at least 6 out of 12 months. The most important point to be borne in mind with regard to such practical training is that it will not do for the students simply to go round the mines or at best work in the mines as supervising staff. Out of 6 months, for 2 months, at least, it should be compulsory for them to be on the labour role as mining labourers on drill machines, mucking, shoveling, trucking, or even timbering with the carpenters. Unfortunately this proposal does not meet with the approval of the people concerned. Since mining is wholly a practical vocation, this is the only way to be equipped with the proper knowledge of how a certain job is done, how theory is put into practice, and where the actual difference between theory and practice lies. Virtually every American mining engineer must begin his career and gain practical experience as a mucker, drill runner, timberman, or hoistman.

Without this practical knowledge a man can never manage a mine efficiently. It is virtually impossible for him to determine quantity and quality of work produced within a fixed time by his employees. I was fortunate enough to have a personal experience of this nature. In fact, whatever success I have achieved in managing a larger number of mica mines is directly attributable to this practical experience, though I must confess I was not free from the common initial distaste for the work.

In 1932, while studying at the Indian School of Mines, Dhanbad, I chose to go to the Mosabani copper mines for practical training. After considerable difficulties and personal efforts, the mine superintendent, Mr. R. J. Cole, allowed me to undergo practical training in these mines. Before being allowed to work in the mines, the condition imposed by Mr. Cole was that a given job must be accepted. This I gladly agreed to. My name was entered on the labour role and the wages fixed were 10 annas per day. During the first few days experience was gained in the sampling and assaying department, and later in the surveying department. After a couple of weeks' training in these departments, underground training on a jackhammer was undertaken. To be sure of putting in full time on the drill I replaced one of the three men on the crew, so that there was no alternative but to work. It would take a few pages to describe adequately my actual feelings on the first two or three days. It was very difficult for me. But on the fourth day things seemed to get easier, and on the fifth day and sixth day the work became familiar and I felt unusually happy because of a colossal increase in self-confidence. In 1933, at the Bawdwin mines in the Northern Shan States, more practical training was gained. I worked as a coolie for Rs.2/8/0 per day, drilling and blasting, with additional work.

On completing this very practical course, I took charge of the mining section of the Indian Mica Supply Co., Ltd., wherein it was possible to realize the value of such practical training. At first it appeared useless, especially for those who were to function as bosses.

In 1935 at our Tharghati mines in the Dhab zone, it was a shock to see drillers drilling holes averaging about 1½ ft. deep. The manager was asked to explain this slow progress, because it was a violation of my standing orders that no hole drilled with a compressed-air machine should be less than 2½ ft. deep. The manager said that, since there was an excessive concentration of very small pieces of mica on the working face, it was impossible to drill holes deeper than 1½ ft. This explanation was unsatisfactory, and I immediately made a trip underground to inspect the working faces and to supervise the drilling. On reaching the working face, I decided to do the drilling and, with the help of two machinemen, drilled two holes, each 4 ft. deep. It was a surprise to the miners, including the manager. Since that time no one has talked to me irresponsibly.

It need hardly be said that this could not have been done without personal experience on drill machines. Otherwise the manager's explanation would have been accepted quietly, and the mining operation would have continued in the usual inefficient manner indefinitely. Thus the value of a little practice in such operations should not be ignored by mine operators or managers.

Besides the problems previously discussed, a manager of a mica mine should possess fair knowledge of magnetic transit surveying and leveling with an ordinary Dumpy level. He may not be required to do the job himself, since in most cases special surveyors are employed to meet this demand in mining, but a knowledge of the same is essential for a manager to be able to check the work of the surveyor, if necessary, and to explain to him in a language he understands what is really wanted. The importance of level sections or longitudinal and cross sections along the productive zone of a vein is not infrequently missed by the mica miners. It is practically impossible to have a true picture of the nature of the vein and the course it follows in the absence of such sections. They should always be plotted with all available geological detail, showing the exact nature and position of the walls and the position of the productive zone in the vein at intervals of approximately 5 ft., as shown in Fig. 40. Since the thickness of mica veins is usually limited to only a few feet, the level sections should be plotted on a scale of not more than 20 ft. to an inch.

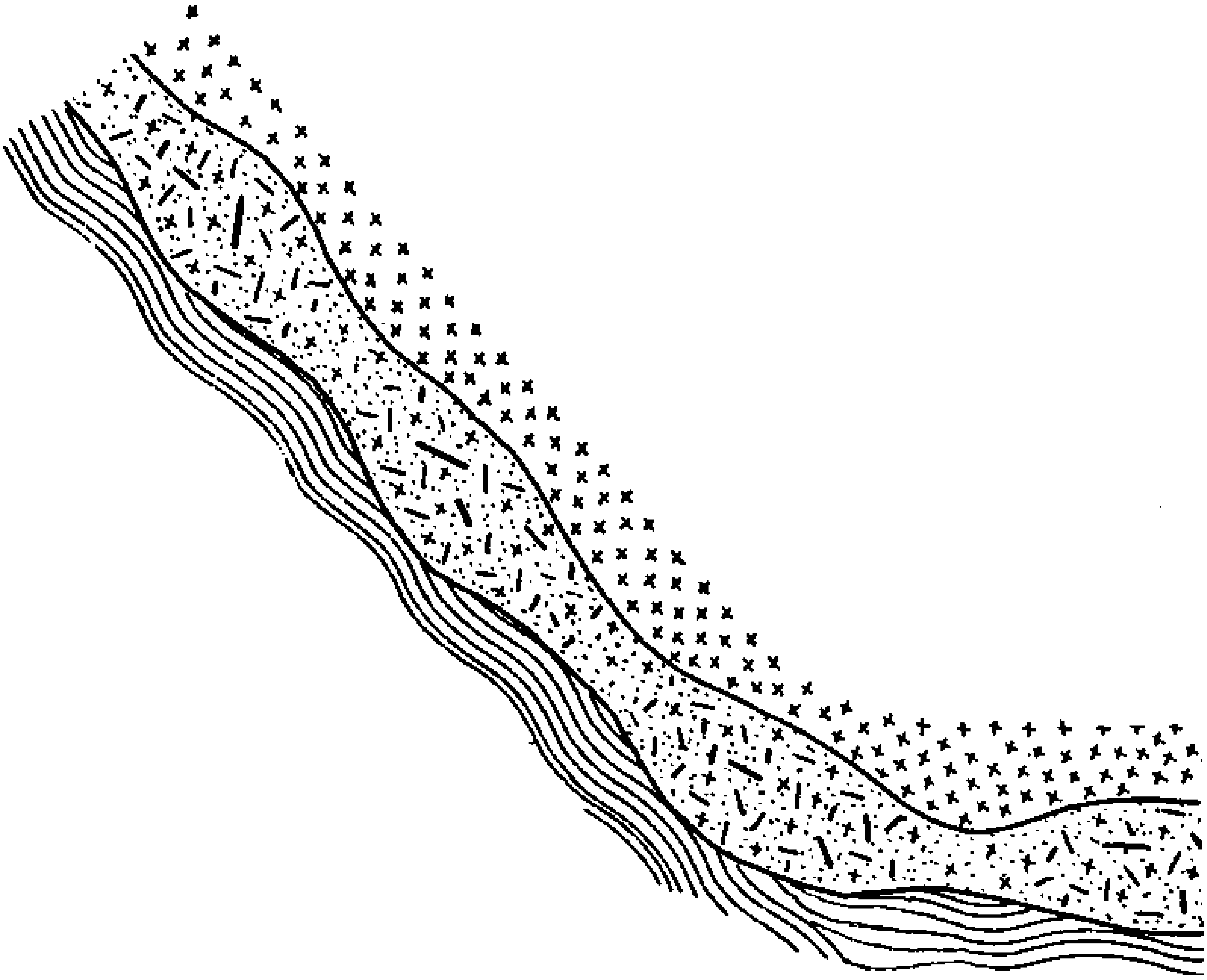

FIG. 40. A collection of underground geological data should be charted on sections to aid in efficient mining. Careful plotting determines the exact location, direction, and width of the productive mica zone and gives a clear picture of how the width of the productive zone and the concentration of mica may vary at intervals along both the dip and the strike.

In addition, a study of the geological aspect of the mica pegmatites is also necessary. A study may not be appreciably helpful at the moment, but if one has a fair knowledge of the geology of the pegmatites, he can at least translate the findings of the local people into data for the geologist and keep a record of his personal observations as well. An elementary knowledge of general geology and petrology of the metamorphics, with various theories in regard to the birth of mica pegmatites, and a fair knowledge of the mica mineralogy and the accessory minerals are essential. With this knowledge of mineralogy, one might examine debris from the mines to ascertain the presence of valuable minerals, and if they are found in appreciable quantities, develop a means of commercial recovery.

The correct selection of mining equipments from the numerous types available in the market needs a detailed study of catalogues of various engineering and manufacturing concerns as well as equipment and supplies advertised in reputable mining magazines. Catalogues contain valuable information about details of equipment, such as capacity, size, weight, power required for driving, etc. The vast scope afforded by these catalogues for a comparative study of equipment by different concerns offers the only way of choosing the best. This study also acquaints a man with the various engineering firms to whom he can look for his requirements. Catalogue study is, therefore, one essential subject required in a mica-mining class.

A mica mine manager should also have a fair knowledge of the various processing operations his product must undergo. This complete training may enable him to take over the full charge of a mica-mining concern as a general manager. To save the colossal waste in the mica factory, responsible heads with technical education will be substantially helpful, and a study of the problem might lead to improved methods of processing.

If students trained in the above subjects have a couple of years of further practical experience in various mines, they will ultimately have the type of technical qualifications useful and beneficial to the mica industry. So long as the extent to which the mica deposits can be developed today remains unchanged, the qualifications aforesaid will be more than sufficient. If, however, future research offers possibilities for developing mica mines to greater depths, students must be more thoroughly informed. At this point it is interesting to state that only a couple of decades ago general opinion held in India was that mica would never be mined below a few hundred feet. Today's experience and knowledge have developed commercial mica deposits to considerably greater depths. Who knows but what research may encourage Indian mica mining beyond 1,000 ft. or perhaps even deeper.

ELEMENT OF CHANCE IN MICA MINING

As the heading suggests, mica mining as a business has, at every stage of production, an element of chance for which there is no close comparison in any other modern industry. To understand the practical effects of the uncertainty in the mining, manufacturing, and marketing of mica, the reader cannot do better than imagine the lot of a slave who has to please a number of masters who are equally whimsical and tyrannical. The behaviour of the masters is wholly unpredictable. That they will give contradictory orders is a certainty, and it is more than likely that none of the orders will be practicable. It is doubtful if any slave can survive such conditions. His chances of having a tolerable living are one in a million. I maintain with a great deal of experience at my back that the lot of the mica miner is no different.

The foregoing is not a false analogy; for the fate of an industrialist is in the hands of innumerable factors governing the cost of production, none of which is constant. Assuming the best that can be made available to an industry, in capital, in efficiency of management and mechanical power, in the degree of harmony in actual working, the various governing factors in industries like textile, jute, sugar, etc., can be foreseen to a nicety; for these, the production is more or less geared to the revolution per minute of the driving machinery at a fixed ratio. Moreover, in such cases the difference between the energy input in various shapes and the energy output in terms of value alone (which ultimately decides the loss and profit factors) has a bearing on factors that are mostly rational. Even the ruling market prices, which might seem irrational, are really intelligible laws of supply and demand. Hence, under normal conditions profit becomes mostly a function of market conditions, other factors of production remaining constant.

In mining, too, there is a reasonable dominance, though perhaps not to the same extent, of rational factors. The prospecting stage, of course, can be entirely an adventure, since it is subject to a number of natural factors completely beyond any human control. This gives a touch of gambling, which is generally inseparable from any mining undertaking. This aspect of risk in mineral occurrences places the mining industry in a very different position from most other industries, though all industries, inclusive of mining, are liable to occasional and unforeseen accidents, labour troubles, strikes, etc.

But mica mining is more subject to such uncertain influences than, say, coal or the working of most metalliferous deposits. In the case of ore deposits, like the lead and zinc ores in the Bawdwin mines of the Northern Shan States, Upper Burma, or the gold mines of the Kolar Gold Fields, South India, or the Mosabani copper mines of Singhbhum, a fairly accurate estimate of the value of the ore body can be obtained by proper proving and sampling and assaying of the ore.

Generally in the mines of the type indicated, the metal content in the ore body usually maintains a fairly uniform average proportion throughout the length and breadth of the productive zones. There may, however, be some occasional patches in the deposits with economically unworkable metal content. But since these are scientifically estimable, the working of such zones of poor concentration may be avoided. Besides these ore bodies, shoots or seams (in the case of coal mines) are much larger in size than even the biggest Indian mica pegmatite and produce only one quality or type of material at a fairly uniform cost under given working conditions.

In a metalliferous mine where the average percentage of the metal content can be estimated fairly accurately, one can form a clear idea of the daily production of the valuable metal, and a comparison of its cost of production with its current market values gives a dependably approximate idea of the daily loss or profit factors.

Moreover, a dependable estimate of the valuable contents of the blocked-out pillars is easily made by proper survey in a coal mine and by preparing assay plans after proper proving, sampling, and assaying of the ore in a metalliferous mine. Thus an approximate picture of the mines' reserves is obtained, which in the final analysis of the economic aspect of the project gives one an idea of the ultimate loss or profit that one is likely to make. Hence, the amount of uniformity that is obtainable in such cases in the factors of production and cost and the assistance that is rendered by modern science in respect of the ore estimation and valuation enable one to reduce all the various factors to one single formula for a dependable study of the day-to-day and ultimate loss and profit factors.

Unfortunately, such methods of proving have been tabooed by nature in the case of the mica-mining industry. Nature is in her most quixotic mood when it comes to the concentration of mica in a mica vein. There are scattered barren patches (as shown in Fig. 15, page 57) even in an explored mine, which make it impossible for one to prepare an assay plan or to have an idea of the reserve in the pillars, as can be done in other metalliferous and nonmetalliferous deposits. Nor has the raising per day even an approximately constant bearing on the production, because the concentration of mica in a pegmatite has a very wide range of variation. Besides, the production obtained from different mines or even that obtained from different parts of the same mine is also subject to a very considerable variation in respect to

1. The soundness of the production of crude mica, on which depends the percentage of the pit-head rejection and ultimately the percentage of the yield of S.D.B.
2. Dominance of larger or smaller grades in the production of bima S.D.B.
3. The average quality of the bulk.
4. The pit-head cost of production.

Assuming perfect management, adequate availability of working factors, and a given level of prices of mining materials and labour wages, the cost of production in a mica mine is governed primarily by the concentration of mica in the vein and secondarily by the degree of natural difficulties like hardness of the rock, water percolation underground, etc.

But besides the cost of production, the other three factors enumerated above play a very important part in deciding the ultimate loss and profit factors. For example, a mine per foot of advance may produce in the average *X* quantity of mica, whereas another mine for the same advance may yield double the output, *i.e.*, 2X quantity. Under circumstances otherwise similar, the cost in the former case will be doubled. But whatever may be the relative cost of production from these two mines, in the final analysis in respect to the ultimate profit, the product of the first even at double the cost may yield better profits than the mine producing larger bulk at practically half the cost by reason of higher recovery of S.D.B. from the crude and the predominance of larger grades in the bulk of the production in the former case.

To understand it properly, let us take a concrete case. A particular mine, *A*, produces 1,000 lb. of crude at a total cost of Rs.500/–. The recovery of S.D.B. from the above crude is, say, 400 lb. and the total value that is recovered, according to the different grades of mica available in the bulk of bima S.D.B., is as detailed below.*

No. 1 and up	3 lb.	@ Rs.9/ –	Rs. 27/ –
No. 2	8 lb.	@ Rs.7/ 4/ –	Rs. 58/ –
No. 3	12 lb.	@ Rs.5/12/ –	Rs. 69/ –
No. 4	22 lb.	@ Rs.4/15/ –	Rs.108/10/–
No. 5	48 lb.	@ Rs.2/13/ –	Rs.135/ –
No. 5½	34 lb.	@ Rs.1/13/ –	Rs. 61/10/–
Nos. 6 and 7	273 lb.	@ Rs.0/ 6/10	Rs.116/ 9/6
			Rs.575/13/6

Now in the second mine, *B*, 1,000 lb. are produced at a cost of Rs.250/–, but in this case, on account of an unfortunate lack of soundness in the bulk produced, the recovery of bima S.D.B. obtained is only 300 lb. and its total value according to the different grades of mica available in the bulk of bima S.D.B. is as detailed below.

No. 2	2 lb.	@ Rs.7/ 4/ –	Rs. 14/ 8/–
No. 3	3½ lb.	@ Rs.5/12/ –	Rs. 20/ 2/–
No. 4	6 lb.	@ Rs.4/15/ –	Rs. 29/10/–
No. 5	26 lb.	@ Rs.2/13/ –	Rs. 73/ 2/–
No. 5½	15 lb.	@ Rs.1/13/ –	Rs. 27/ 3/–
Nos. 6 and 7	246½ lb.	@ Rs.0/ 6/10	Rs.105/14/3
			Rs.270/ 7/3

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* The price per pound of the various grades of mica has been derived from Table 52, p. 293.

From the above two examples, it is clear that on account of the superiority of the former over the latter in respect to soundness and grading, the first mine yields even at double the cost of production a much larger profit than the second mine. The profit earned from the first mine may further be enhanced or the difference of profit between the two mines caused by the factors of soundness and grading may be narrowed down to nil by virtue of the average quality of the product of one being superior to that of the other (as will be explained further along).

A substantial producer has to work a number of mines on account of the smallness and the most uncertain behaviour of the mica deposits. Hence, to afford a clearer understanding of the subject, it will be most useful to consider the results obtained from a number of prospecting, exploring, developing, and stoping mines of a big concern. Since the figures are trade secrets, which would not be proper to publicize through the pages of a book, let us illustrate the facts with the aid of algebraic symbols.

Table 4 gives the details of production obtained from various mines worked by a concern in year *X* with percentage of pit-head rejection, yield of S.D.B. over the sorted crude, and yield of various grades in the bulk of S.D.B. recovered from the sorted crude separately for each mine. The money spent in mining mica and the value recovered from the sale of it are expressed in terms of x and y, x being the unit of production while y is the unit of value both for expenditure and recovery. Column 11 gives cost per unit production of unsorted crude, while column 12 gives the value recovered per unit production of the same.

A study of Table 4 shows clearly how in practice the production obtained from different mines varies widely in respect to soundness and the proportion of larger and smaller grades and also how, besides the cost of production, the above variations govern the value of the product and the ultimate loss and profit factors.

For example, though the actual production of the mine *C* in Table 4 is appreciable and the cost of production is practically half that of the product of the mine *F*, on account of a number of natural factors adversely affecting the soundness of the bulk of the production of the mine *C*, the pit-head rejection is about 34 per cent higher

TABLE 4

Expenditures and Recovery in Year *X* from a Number of Mines

Mines	x*			*Average per cent on sorted crude*				y			
	Production of crude mica	*Per cent of pit-head rejection*	*Production of sorted crude mica*	*Bima S.D.B.*	*4 and up S.D.B.*	*5 and 5½ S.D.B.*	*6 and 7 S.D.B.*	*Total mining expenditure*	*Approximate total value recovered*	*Cost per unit production of crude*	*Approximate value of unit production of crude*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A.....	$147x$	22.4	$114x$	38¼	4	10	24¼	$157y$	$405y$	1.07	2.75
B.....	$24.5x$	32.7	$16.5x$	34½	2½	6	26	$59y$	$39y$	2.42	1.59
C.....	$38x$	50.0	$19x$	33½	2	6	25½	$45y$	$40y$	1.18	1.05
D.....	$26x$	23.0	$20x$	43	5½	10	27½	$74y$	$107y$	2.85	4.10
E.....	$28x$	32.1	$19x$	35½	1¾	6¼	28	$72y$	$35y$	2.57	1.25
F.....	$36x$	16.6	$30x$	40½	5½	10	25	$98y$	$118y$	2.72	3.28
G.....	$6x$	41.6	$3.5x$	38	3½	8	26½	$25y$	$17.5y$	4.17	2.92
H.....	$29.5x$	25.4	$22x$	32½	½	5	27	$47y$	$31y$	1.59	1.05
I.....	$12.5x$	20.0	$10x$	36¾	1¼	5	30½	$20y$	$19.5y$	1.60	1.56
J.....	$0.19x$	10.5	$0.17x$	21¼	...	2½	18¾	$3y$	$0.13y$	15.79	0.68
Pros...	$44x$	43.2	$25x$	35¾	¾	4¼	30¾	$76y$	$40y$	1.73	0.91

* x = unit of production expressed in terms of weight.
y = unit of expenditures (operating costs).

than in the product of the mine *F*. Hence, the recovery of bima S.D.B. from the bulk of crude, as well as its average grading, is much poorer than that of the product of the mine *F*. Thus in spite of its producing mica at a very low cost, mine *C* becomes a losing concern, whereas mine *F* yields a good profit. If, instead of being 50 per cent, the pit-head rejection of the product of the mine *C* had been 20 per cent, even without any improvement in the grading, considering the low cost of production, the mine would have yielded a better profit than mine *F*, for the total value recovered, instead of being 40*y*, would have been about 60*y*.

To arrive at more conclusive results, let us examine the figures of the next year for the same mines. Table 5, like Table 4, gives figures relating to the mines, worked by the same concern during the next year, *Y*.

Though the mines *A* and *D* do not appear in the next year's picture, all the other mines show entirely different results in practically all respects. For example, mine *B* in year *X* was a losing concern partly on account of high pit-head rejection and partly on account of the poor average grading of the production of bima S.D.B. The loss cannot possibly be attributed to the cost of production, for mines *D* and *F* (even at a slightly higher cost of production) show appreciable profit, on account of their product being considerably superior to that of the former both in soundness and in grading.

This mine, however, shows a remarkable improvement in the next year, *Y*, so far as the production is concerned. The concentration of mica in the vein has become very rich, and the cost of production as well is less than half of what it was in the previous year. But as fate would have it, on account of a serious drop in the soundness of the production, resulting in a much heavier pit-head rejection, and some amount of deterioration in the average grading as well, mine *B* in year *Y* continues to be a losing concern.

Mine *A* was exhausted during the year *X* on account of the completion of the stoping operations which were being carried on long since.

Mine *D*, being a small pocket deposit, was also exhausted during the same year.

TABLE 5

Expenditure and Recovery in Year *Y* from a Number of Mines

	x *			*Average per cent on sorted crude*				*y*			
Mines (1)	*Production of crude mica* (2)	*Per cent of pit-head rejection* (3)	*Production of sorted crude mica* (4)	*Bima S.D.B.* (5)	*4 and up S.D.B.* (6)	*5 and 5½ S.D.B.* (7)	*6 and 7 S.D.B.* (8)	*Total mining expenditure* (9)	*Approximate total value recovered* (10)	*Cost per unit production of crude* (11)	*Approximate value of unit production of crude* (12)
I.....	95*x*	24.2	72*x*	42½	3¾	9	29½	200*y*	256*y*	2.1	2.7
B.....	109*x*	59.6	44*x*	32	2½	5¼	24¼	120*y*	104*y*	1.1	0.95
C.....	69*x*	42.0	40*x*	31¼	2¼	5¾	23¾	93*y*	84*y*	1.35	1.22
E.....	70*x*	28.6	50*x*	35	2½	7½	25	86*y*	130*y*	1.23	1.86
F.....	43*x*	15.1	36.5*x*	39½	6½	9¾	23¼	75*y*	161*y*	1.74	3.74
K.....	109*x*	72.5	30*x*	33¼	1	6	26¼	42.5*y*	52*y*	0.39	0.48
G.....	26*x*	59.6	9.5*x*	37¾	4	9	24¾	16*y*	34*y*	0.62	1.30
H.....	161*x*	57.8	67*x*	33¾	1½	6¼	26	125*y*	136*y*	0.78	0.84
J.....	14*x*	60.7	5.5*x*	23½	1	4½	18	15*y*	7.8*y*	1.07	0.56
Pros...	50*x*	48.0	26*x*	33	1¾	6	25¼	70*y*	49*y*	2.40	0.99

* *x* = unit of production expressed in terms of weight.
y = unit of expenditures (operating costs).

Mine *C*, which was also a losing concern in year *X*, continued to be unprofitable in year *Y*, although it yielded practically 80 per cent more production than in the previous year. This is because, besides the increase in the quantity of production, which is remarkable, there was no appreciable improvement in any other factor. Whatever little improvement there was in the pit-head rejection and the average grading of its product was neutralized by a slight increase in the cost of production and a little deterioration in the recovery of bima S.D.B. Hence the magnitude of loss remains practically the same in both the years.

Mine *E*, which was the most unprofitable concern in year *X*, has, however, shown a remarkable improvement in year *Y*. The production obtained was more than double, and on account of sudden enrichment of the vein, the cost of production dropped to practically half of what it was during the previous year. There was also an appreciable decrease in the pit-head rejection, with a remarkable improvement in the proportion of larger grades in the production. Hence, as a result of an improvement both in the cost of production and in soundness, as well as in the average grading, the mine yields a good profit. Similarly a study of the figures relating to all the subsequent mines will account for the improvements effected in them during the next year *Y*.

During this year (*Y*), a new mine, *K*, appears on the record, which again, in spite of heavy pit-head rejection and poor grading, shows appreciable profit. This is a typical example of how extraordinary richness of the concentration of mica in a deposit enables one to produce mica at an extremely low cost and thereby make appreciable profit irrespective of the degree of soundness or grading. This mine in the previous year was a very shallow pit with a very poor concentration of mica and was hence placed under the head of prospecting.

There is however a very serious departure from the general rule in the case of mine *D* in the year *X*. Mine *D*, with an even heavier pit-head rejection than mine *F* and practically similar cost of production, recovery of S.D.B. from the crude, and proportion of larger grades in the same, shows an appreciably better recovery of value per unit quantity of production than that of mine *F*. This is because of a marked difference between the quality of the products of these two mines. Such variation of value recovery on account of quality difference has a wide range, say, anything between 10 to 50 per cent, depending partly on how far the quality of one is superior to that of the other and partly on the demand for higher quality mica blocks. To understand better how this variation affects the valuation of a mine's product, let us take a concrete case.

The calculation on page 295 of the value of bima S.D.B. has been made according to the value of different grades of S.D.B., as has been calculated in the various tables in the chapter on A Study of Descriptive and Analytical Statistics of Mica. In making the above calculations, a bulk of average-quality S.D.B. of each grade has been taken into consideration, but there are deposits that do not yield any good stained or better quality mica, and the production consists chiefly of "stained" quality and "splitting" quality blocks. Hence, let us consider an example of this type to obtain an idea of the difference in price that will be made by the absence of higher qualities from the bulk of a mine's production.

Let us, for example, analyze 1,000 lb. of No. 5 S.D.B. produced by a mine of the kind alluded to above. Table 6 gives us the required figures. According to the above calculations, the value recovered is 17 per cent less than in the case of an average-quality S.D.B. (as shown in Table 49, page 291). Hence the above analysis clearly shows how, apart from all the difference that the proportion of larger or smaller grades makes in the ultimate value of the product of the mines, it is further appreciated or depreciated considerably by the factor of quality.

Besides all the variations that are observed in the products of different mines, as have been explained in the previous pages, the product of the same mine is subjected to appreciable variation in respect to both soundness and grading at very short intervals in the life of the mine, say even 4 or 5 days. Table 7 explains this clearly. The production of the fourth day in the table shows a recovery of 10.78 per cent of No. 4 and larger grades and 17.5 per cent of Nos. 5 and 5½ from the bulk of S.D.B. But on the day following, the above proportion of No. 4 and larger grades shoots up to 14.4 per cent and that of Nos. 5 and 5½ drops down to 10 per cent. A study of the table will show even more serious variations.

TABLE 6

Analysis of 1,000 Lb. of No. 5 S.D.B. from a Mine

	Weight		*Rate*			*Value*		
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*
No. 5 stained and book block...	672	11	3	0	0	2,018	1	0
No. 5 heavily stained..........	41	1	1	14	0	77	0	0
No. 5½ stained...............	16	0	2	0	0	32	0	0
No. 5½ heavily stained........	2	6	1	4	0	2	15	6
No. 6 stained.................	16	12	0	14	0	14	10	6
No. 5½ book block............	43	0	1	6	0	59	2	0
No. 5 loose splitting chillas.....	77	12	1	4	0	97	3	0
No. 5½ loose splitting chillas...	18	12	0	14	0	16	6	0
No. 6 first-quality loose splitting chillas.....................	28	8	0	9	9	17	6	0
Cuttings.....................	83	2						
Total......................	1,000	0	....			2,334	12	0

A study of Table 4 also gives some valuable information in respect to how a mica-mine operator is completely helpless in regard to the amount of profit that he earns in a year *X*. Mine *A* produces mica at a very low cost. The production of this mine has a very reasonable pit-head rejection, with a fairly high percentage of recovery of bima S.D.B. from the crude and equally high proportion of larger grades in the bulk. But as is obvious from the disappearance of this mine from the records of the next year, the mine was exhausted during the year *X*. Hence almost the entire production came from stoping operations. The mine was undoubtedly very rich, and even if the production, instead of being obtained from stoping operation, had been obtained from purely development faces at even double the cost, the profit that it would yield would be considerable.

TABLE 7

Daily Variation of Soundness and Grading of S.D.B.

Date	*Crude issued for sickle dressing*		*S.D.B. received*		*Per cent of S.D.B. recovered*	*Per cent of various grades of S.D.B.*		
						No. 4 and up	*Nos. 5 and 5½*	*Nos. 6 and 7*
	Maunds	*Seers*	*Maunds*	*Seers*				
1	10	0	6	5	61.27	15.23	15.00	30.94
2	8	30	5	15	63.09	13.91	16.87	30.31
3	7	20	4	20	60.00	12.97	14.84	32.19
4	6	10	3	10	60.00	10.78	17.50	31.72
5	6	0	3	25	58.60	14.38	10.31	33.91
6	7	0	4	8	60.03	15.47	14.38	30.16
7	6	20	4	0	61.42	14.38	13.91	33.13
8	6	0	3	25	60.47	13.59	14.22	32.66
9	5	20	3	20	63.60	13.13	13.91	36.56
10	6	0	3	30	62.19	13.28	13.91	35.00
11	5	0	3	5	62.03	13.91	15.31	32.81
12	5	0	3	5	59.34	13.40	15.94	30.00
13	6	0	3	32	63.29	17.66	15.47	30.16
14	7	0	4	18	63.59	15.47	14.06	34.06
15	6	0	3	30	62.49	14.36	13.91	34.22

But such rich deposits must be treated as exceptions, and, in point of fact, a major portion of the enormous profit earned by this mine in the year *X* was neutralized by most other mines in which the work of exploration had to be carried on. Unless these mines had been explored at the cost of this profit with the absence of the mine *A* from the picture, one can well imagine the results for the year *Y*. Hence for a substantial producer of long standing, such sacrifice of profit from the long-term point of view is unavoidable. It is only through patient adherence to mines like *E, G, H, I,* etc., that the second year's mining operations could be made profitable. It is purely a matter of chance that the efforts made in the year *X* for exploring new deposits were crowned with success, or else in the absence of a rich mine like *A,* the year *Y* would have been a very stormy one for the concern, on account of factors over which it had no control whatsoever.

Besides, as is obvious from the tables, considerable sums had to be spent on prospecting in both these years, without full recovery of the capital investment, though in the second year, fortunately, the expensive efforts were rewarded by the discovery of the mine *K*. But this sort of loss in prospecting operations carried out departmentally is part of the game. At the time of the final abandonment of the prospecting pits some production is obtained from the sides of the pits or very small pillars (at the best two or three in number) at comparatively lower cost. Such recovery of mica before final abandonment affords further compensation, but not always to the full extent.

Through the use of modern mechanical equipment and granted an adequate supply of efficient labour (which is not quite reliable for reasons explained in the chapter on Labour), it may be possible to control the cost of producing a unit quantity of broken material from the mine. But in the light of all that has been discussed above, it is completely beyond one's power to have any control over either the cost of production of the valuable material, mica, or the nature of the product. One has to take what nature has deposited or destiny has in store for him, and it is at this juncture that the element of chance in mica mining is at its peak. The whole thing amounts to one's dealing in numerous types of materials with a very wide variation between the prices of the highest and the lowest grade or quality (clearly explained by Table 9 on page 136), without any control whatsoever over the production of what is in demand and/or avoidance of what is not. One has to mine the whole bulk that is in a mine, which again is a heterogeneous mixture of all grades and qualities of mica.

On the demand side, there never is a uniform demand for all the grades and qualities produced, and the prices of the various categories of mica do not therefore vary uniformly. The unwanted categories are affected adversely by the poor demand, which may, unfortunately, coincide with high output. Those which are in demand fetch high prices, while those which are not wanted cannot be sold even at disproportionately low prices.

For example, according to the Joint Mica Mission schedule of prices, the basic price of No. 5 book-form splittings was Rs.4/– per pound, while that of No. 5 second-quality condenser films was Rs.7/8/– per pound. Hence, the difference between the prices of the two when there was a uniform demand was practically 90 per cent. But today, since there is very little demand for No. 5 second-quality condenser films and that for No. 5 book-form splittings is very active, the latter, according to the United Kingdom government's latest revised sale price (fixed for selling the government surplus stocks of mica purchased during World War II), can be sold for at least 15s. 6d. ex: factory, while the former cannot be sold in substantial quantities at even 18s. 6d. Hence, the difference between the prices of these two materials has narrowed down to about 20 per cent.

With such a narrow margin of difference between the two, it does not pay a manufacturer to produce condenser films profitably from a bulk of No. 5 good stained mica, the price of which, as has been fixed by the United Kingdom government, comes to about 12s. 9d. ex: factory India. What one obtains for No. 5 book block by selling 5 book-packed splittings at 15s. 6d. ex: factory comes to about 12s. per pound. Hence, by selling good stained blocks, one gets only about 6 per cent more value, and if the good stained blocks are employed for manufacturing condenser films, one no doubt gets about 20 per cent more, but on account of the difference in the cost of producing book-packed splittings and condenser films, this difference disappears. In these circumstances, one has either to sell the good stained blocks practically at the price of stained or even book block for a quick turnover, or has to keep such higher quality blocks in stock till the demand for them becomes active.

Hence, unlike other mining industries, mica mining has highly complicated problems of marketing. At times a major part of the profit, even when it is earned, remains blocked up for years in the shape of unsold stocks. The position of the owner of mica mines in such circumstances is far from enviable, especially when such unfortunate lack of uniformity of demand occurs and at a time when the cost of production is riding a high tide. Between the vagaries of production and costs on the one side and the vagaries of demand

and prices on the other, the mica miner is nearly always trapped.

If the difficulties on the production side are great, those on the side of marketing are even greater. Indian mica suffers from a total absence of an internal market and the consequent difficulty of the producer for getting a close or intimate knowledge of the consumption side of his industry. The consumer, therefore, may be, and often is, in a position to control the prices of mica by playing the market and thereby putting the staying power of the producer to a severe test. The bargaining power of the producer, already affected by the peculiarities of mica production and the variegated nature of his stocks, is further whittled down by the advantages enjoyed by the buyer. It will be seen that, if the general conditions do not establish a balance between costs and prices, it becomes extremely difficult for the producer to recover even his working cost by selling all categories in demand. Even when profits are made, stocks of the unwanted categories produced at a very high cost make the estimated profit doubtful, for by the time the demand for the blocked-up categories comes up, the general demand subsides and they have to be sold at a lower price. Besides, considerable accumulation of such materials in stock makes a producer anxious to convert into cash as soon as the demand comes. Hence, this accumulation stands little chance of ever getting proper average value. More often than not it happens that, when there is a sudden spurt in demand for the categories that had been piled up in the past, the producers are unable to foresee the real intensity of the demand and rush to dispose of the stock, with the result that the bulk of the prized stock is disposed of before the prices reach their peak.

This is exactly what happened during the year 1936-1937. There was practically very little demand for splittings prior to the year 1935 for several years and a huge amount of capital was blocked up in the stock of the producers as unsold stocks of mica splittings.

A reference to Table 43 on page 284 will show that the demand started looking up a bit in the year 1935, gradually increased in the year 1936, and reached its peak in the year 1937, with a sudden fall in the year following. The quantities of splittings that were sold during the year 1935-1936 were sold at very low prices and when the intensity of the demand was felt by the producers in the year 1937 prices started being pushed up to market levels. But by the time they reached a reasonable level there was a considerable drop in the demand and the price structure again collapsed. Thus the average price obtained for the piled-up stocks of splittings during the years 1936-1937 was far from being economic.

Thus the situation that results at abnormal times like the present, when one loses all control over the cost of production, is not to the abiding good of either the consumer or the producer. On the one hand, the buyer detests a rapid increase in the prices of the categories he wants and on the other hand the producer gets practically nothing out of it but rather stands to lose appreciably on account of the factors enumerated above.

Foreign buyers of India mica, who are interested in and have knowledge of only a part of the trade, have no idea of the complexities with which the miners have to contend and mistake a rise in the price of one category as an index of undeserved prosperity for the producer. The foregoing should help the trade and all concerned to see the facts in better proportion.

The working efficiency in the mica mines in general is extremely low. The behaviour of mica pegmatites is subject to the gravest uncertainties. Added to these is the complete dependence of the entire operation in a factory upon manual labour and, before a bulk is processed to a marketable standard, it has to pass through a number of hands.

The first operation of rifting and sickle dressing the crude books calls for extremely careful supervision, since otherwise the bulk of the production stands a chance of serious undergrading with an undesirable production of excessive cuttings. Similarly the factor of waste is so vital in all other operations in a factory that, unless adequate and careful supervision of the type called for is ensured, it may lead to far-reaching consequences. This is quite unlike the subsequent treatment that an ore from a metalliferous deposit is subjected to. The extraction of the valuable metal from the ore is done mechanically through highly scientific methods, and thus the maximum recovery at the lowest cost can be obtained. But since the entire operation in a mica factory is absolutely unscientific, the ultimate recovery of valuable material from the crude depends solely on careful supervision.

In view of the numerous natural and circumstantial difficulties detailed above, mica mining assumes a much more speculative character than any other mining industry; and it is hardly possible to reduce all the factors deciding the ultimate fate of the industry to a single formula (as is possible in the case of other metalliferous and nonmetalliferous deposits), which could give one a dependably approximate idea of the loss or profit that one is likely to make during the course of working a mica mine.

Because of the unduly large element of uncertainty involved in practically every part of this industry, mica is placed along with the mining of precious stones in a special category apart from all other mining industries.

Besides, in view of the colossal element of chance involved in the entire operation of mica industry from the beginning to the end, it may be ventured that, though there are a few exceptional cases where a lucky coincidence of uncertain factors has made for large fortunes, a modest return is normally a rich prize.

CHAPTER 6

Management of Mica Mines

In view of the unique features of Indian mica mining it is natural that management is confronted with special problems, the results of which, in many instances, would be an unfair test of managerial efficiency.

Modern methods of industrial analysis and the application and study of statistics by anyone who has the enthusiasm to use these methods will help managerial direction considerably. Though the net result of a constructive project is a function of a number of factors, both constant and variable, each factor is like the different links of a chain. The disturbance effected, for one reason or the other, in any one of the links is passed on throughout the entire length of the chain. In other words, all the factors involved in a project are interlinked with one another in such a way that the disturbance of one factor affects the operation of all other factors; and unless complete harmony is achieved in the various functions of all these factors with perfect regularity, a constantly uniform result is not obtained. But such regular harmony is impracticable and it is as a result of this that the question of scientific management gains so much importance, especially in an industry like mica mining, where not a single factor has any degree of constancy.

The extent to which this industry is influenced by unusually varying or fluctuating factors in the matter of the quantity and the cost of production has been dealt with elaborately in the foregoing pages. All such fluctuations and uncertainties are mostly beyond human control so far as mica mines are concerned. However efficient the management may be, the cumulative effect of all the variations of these inconstant factors is felt in full on the average net result.

These peculiar circumstances require special efforts for the estimation of the efficiency of the management.

The problem, therefore, is how to arrive at a true value of the efforts put in by the manager, especially when results drop down considerably below the expected level or when on a particular day the cost of production rises considerably. If a check system of some sort is made available to the governing head at headquarters, accounting for such contingencies, and if it is satisfactorily proved that fluctuations are due to factors beyond human control, then the governor will have the satisfaction of knowing that he has obtained the best possible results under existing circumstances.

Moreover, if results are not satisfactory from the economic point of view, he is enabled to arrive, in a methodical way, at the real or the most likely source of his trouble. He can decide whether the poverty of the vein is the cause of trouble or if it is the working difficulties. If it is the former, he is guarded against any further loss and he moves cautiously in the operation of the mine, taking it to be a purely exploring adventure. But if the failure is attributable to the latter, he tries to solve the difficulties in the best possible manner. However, in any case, the position of the manager is rendered quite safe, and he does not fail to get due appreciation from the governing body. However, in case such checks reveal carelessness on the part of the mine manager, it helps the governing body to take immediate action to put a stop to this most serious defect.

In the absence of a system of checking operating progress the governing head's inability to cope with the colossal amount of work involved in obtaining a true picture invariably makes him suspect the honesty of his subordinates, who are working miles away from him. And his suspicion makes him susceptible to talebearing and unfair faultfinding by persons who want to be in his good graces. Such situations, coupled with the inability of the governing head to get to the bottom of things with reasonable ease, creates such an unhealthy atmosphere that most of the honest members of the staff fall a victim to unjust vilification, while the dishonest elements continue to thrive by pleasing the favourites of the "boss" at headquarters.

Requisite checks and results of tests on daily working factors may be obtained from statistics collected from the mines, and their gist may be made available in tabulated form to the governing head. But since a large concern has a number of mines, the total magnitude of these statistics becomes so great that it is not possible to get a true picture from the many studies necessary and determine all the troubles that affect the operating results and objectives. After all, there is a limit to one's ability to battle with figures. In such cases what is essentially needed is a method that will make all the contingencies so conspicuous that one may straight away put his finger on the factors that affect the expected result on a particular day or days in comparison with what is generally obtained under normal conditions. Such comparative ideas can be obtained only by taking graphical representation of the statistics, *i.e.,* by maintaining analytical statistics.

To work out a solution on these lines for the mica industry, one must take a common-sense view of the entire mining operation and find out how this can be achieved. Once it is explained that mica occurs in a rock associated with other minerals, it becomes a matter of common sense that, to separate mica from its associates and to have it in one's own possession for personal benefit, one must break the rock. Since the hardness of the rock offers tremendous resistance, one must use modern technical know-how to break it in sufficient quantity. To do this, one must drill holes into the rock and then blast with explosives. Hence production becomes directly correlated with the amount of drilling and successful blasting. For example:

1. The total amount of drilling is 100 ft.
2. The total quantity of rock broken after a successful blasting of the above drilling is 100 cu. ft.
3. Production of crude mica thus obtained is 10 maunds.

According to the above, 1 ft. of drilling produces 0.1 maund of mica. Now suppose for drilling the 100 ft., Rs.200/– was spent. The cost per foot of drilling would then be Rs.2/– per foot and the cost per maund of crude mica would be Rs.20/–.

If it is desired that the cost of production should remain constant, the other two factors, *viz.,* the cost per foot of drilling and the production per foot of drilling, should also remain constant. But since in practice uniformity is tabooed by nature, constancy in these two figures is impossible. Though the variation of these two factors is inevitable, such variations can easily be accounted for, and to account for them is the first step in approaching a solution to the problem.

The cost per foot of drilling may vary because of one or more of the following conditions:

1. Inadequate labour supply.
2. Mechanical inefficiency.
3. Inefficiency of the management.
4. Ineffective drilling or blasting.
5. Mechanical breakdown and accidents.

1. In case of inadequate labour, one fails to supply proper load to machinery set up for the management of the mine, as well as the mechanical units installed for a particular amount of work.

Failure to obtain the desired work from these two factors does not exempt the mine operator from paying their fixed charges. Consequently the total cost of these two factors must be borne by the lesser amount of work, which ultimately increases the cost per unit of work, the intensity of which depends on the degree of deficiency of the operating load.

2. If the mechanical units do not function efficiently because of, say, improper fuel or wearing out of some parts, like fuel pumps or the cylinder of the engine, or any other such defect, which does not disable the unit but renders it incapable of coping with the normal load, the amount of work that would be expected under normal conditions fails to be done, and the entire cost of labour and management has to be borne by the comparatively lesser amount of work, which, ultimately, increases the cost per unit work done.

3. If in spite of adequate labour supply and perfect mechanical operation, the management should fail to be vigilant and labour gets a free hand, the desired amount of work is not obtained. In fact, this is the most serious contingency, since it may lead to a large decline in the expected amount of work under normal conditions. Under conditions 1 and 2, one can at least get the best that can be obtained, but in this particular case, the slackness of management, there can be no question of getting the best, and whatever

amount of work is obtained must be attributed to the luck of the proprietor or the shareholders.

4. If in the case of improper placing and pointing of holes or some defect in blasting operation, some holes are not blasted partially or wholly, the amount spent on such holes is wasted and this has to be borne by the smaller amount of work done.

5. Accidental breakdowns are, of course, beyond human control, though one needs to be satisfied that enough precautionary measures are taken to prevent such accidents.

This is a short résumé of how the cost per unit of work done can be affected, disturbing the uniformity of the desired result. Now let us consider the second vital factor affecting the ultimate cost of production, which is the production per foot of drilling. While the cost per unit of work done is fixed by certain limitations, such as maximum labour efficiency and maximum mechanical efficiency, the second factor is not governed by any hard and fast rule. The production per foot of drilling may drop to zero or may increase considerably from the average, depending entirely on the concentration of mica on the working face on a particular day, which is subjected to wide variations.

The above discussion leads to the conclusion that, for a rough diagnosis of the "disease" affecting the ultimate cost of production, consideration should be limited to two factors:

1. The cost per foot of drilling.
2. Production per foot of drilling.

The cost per foot of drilling remaining the same, if the production per foot of drilling decreases, the cost per unit quantity of production increases and vice versa. Hence, the moment one detects an increase in the cost of production, he should find out which of the two causes has affected the cost, and, after ascertaining the same, proceed further with the investigation.

The problem now is how to simplify the procedure of the investigation so that, without any appreciable sacrifice of personal time or energy, the governor can put his finger straight on the factors and the subfactors causing the disturbance. As has already been said, this can be achieved only by a graphic representation of the daily work done by all the working factors. This is explained by Fig. 41.

The daily cost per unit quantity of mica is plotted against date and the curve Z is obtained in Section 3 of the graph. This curve

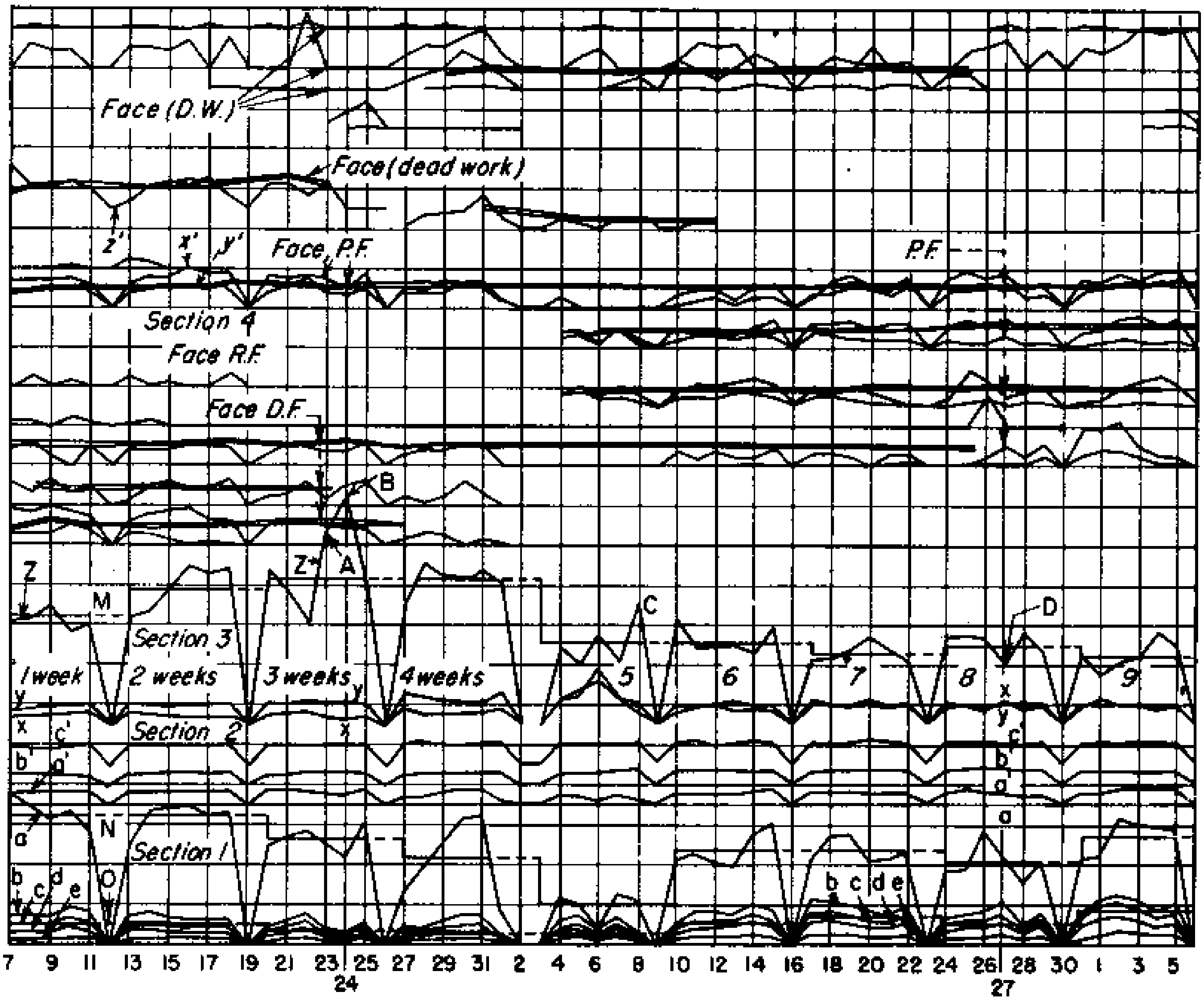

FIG. 41. "Know what" graph explaining how regular collection of statistics from the mines regarding daily production, various working places, and working factors and plotting them on graph paper affords a clear, comparative study of day-to-day operation progress in the mines. This affords rapid over-all inspection for the management.

is governed by two other curves, *viz.*, x and y, x representing the daily production obtained per foot of drilling, and y the daily cost per foot of drilling.

To explain the rise and fall of curves x and y, the graph is further supplemented by a number of curves in Sections 1, 2, and 4 which are as follows:

Curve a represents total footage drilled in the mine.

Curve b the total production (crude) obtained against this drilling.

Curve *c* the total sorted production obtained from the above crude.

Curve *d* the total quantity of small-size mica in the above bulk.

Curve *e* the total quantity of medium-size mica in the above bulk.

The curves *c, d,* and *e* do not help in the judgment of the efficiency of the management, but these are included in the graph so that at a glance the governing head may also get an idea of the intrinsic value of the mica produced.

All these curves from *b* to *e,* under normal conditions, should run parallel to each other for a particular mine, as they normally do, as shown in the curve diagram.

The curve *a,* under ideal conditions, should also run parallel to the curves below, but since the concentration of mica in a mine fluctuates very frequently, in practice it is impossible to expect the ideal behaviour of the curve.

Section 2. The curve *a′* represents the number of machines operated per day. A fall in this curve suggests inadequate supply of labour.

Curve *b′* represents the total footage drilled per hour per machine, thus determining the efficiency of management and of compressed-air power as well.

The curve *c′* represents the explosives used per foot of hole, which for a particular mine should be fairly constant.

Section 4. In this section the work done on each face and the production obtained from such work with some other details are plotted.

For example, the curve *x′* in this section represents the total footage drilled per day on a particular face and *y′* represents the daily production obtained from such drilling. The curve *z′* represents the total footage drilled on another face, which, being a shaft in this particular case, is a barren face. Hence it is a single curve without its other associate, *i.e.,* the production curve.

In Sections 1 and 3, there are some horizontal lines (solid and dash) stepping up and down. They represent the weekly average cost of production (line *M*), average drilling done (line *N*), and average production (line *O*) obtained over a week.

Now let us proceed with a short study of the graph to understand how such plotting helps a man to detect at a glance the contingencies affecting the desired result.

At first sight (Section 3) the idea conveyed is that, in the second, third, and fourth weeks, the average cost of production (line *M*) was higher than in the succeeding weeks, though there is not any remarkable variation in the amount of work done (lines *N* and *O*, Section 1) during the whole period covered by the graph, with the exception of the fifth week. Curves *x* and *y* (Section 3) emphasize this and show that, for practically the same amount of work, the production (line *O*, Section 1) obtained during these three weeks was less than in the succeeding weeks, which is further confirmed by Section 4, showing useful work in only one face and dead work in a number of faces. During this period, points *A* and *B* on the curve *Z* (Section 3) are so conspicuous that, apart from the explanation with regard to the general rise in the cost, an unusual jump of these two points compels attention and calls for special explanation.

Let us first take the point *A*. When we travel down to the curve *y*, on the particular day (the twenty-third), we find that the cost per foot of drilling has rather dropped slightly; thus it is useless to bother about Sections 1 and 2 of the curves. But the curve *x* shows a disproportionate fall of production per foot of drilling. Now to explain this let us go up to Section 4. The curves in the section show an excess amount of work done on barren faces (indicated as Face D.F., dead face, and Face D.W., meaning dead work, *i.e.*, shaft sinking; cross cutting) on this day, while that on the only productive face (Face P.F.) is less than on the previous day. Thus the drop in the curve *x* and the rise in the curve *Z* (cost of production) are explained.

Now coming to the point *B*, we find an increase in the cost of drilling, as is indicated by the rise of the corresponding point on the curve *y* on that day (twenty-fourth), with a further decrease in the production per foot of drilling on the curve *x*. This calls for the investigation of all the sections. Coming down to Section 2, curve *a′* (machines), the number of machines worked on this particular day was less, which consequently affected the total footage drilled, thus suggesting inadequate labour supply as the proper diagnosis.

Inspecting Section 4 of the graph, we find a considerable drop in the drilling on the only productive face on this day (twenty-fourth), with an excess of drilling on the barren faces. Thus since all the factors are disturbed on this unfortunate day, the unusual rise in the cost of production is but natural.

The general picture presented by the curves of the succeeding weeks is quite a happy one, though the fifth week is not so good from the point of view of labour supply. During this week, though the average drilling per day is less than even half of what it was in the previous week (as indicated by the vertical fall of the weekly average line), the average production (line *O*) obtained is the same. A review of Section 4 explains it clearly, showing practically total absence of dead work during this week and succeeding weeks as well, since the appearance of a number of new productive working faces contributes substantially to the production.

Let us now take a point which is pleasing to the eyes, *i.e.*, a considerable drop in the curve *Z* at a certain point *D* on a certain day (twenty-seventh of following month), showing an unusual fall in the cost of production. On this particular day what we find is that the curve *x* rises over curve *y*. This has been caused (as is explained by Section 4 of the graph) by a sudden enrichment of two working faces at a time on this lucky day.

The entire graph covers working details of 70 days, and to check the work in detail as explained above takes only a few minutes. It is the application of such methods that can reasonably simplify the problem of management. Without such a check, life for the governor of a group of mica mines would be troublesome to say the least. This is just a short description of this simple and effective system of check-up; to explain it fully in all its details would require more space than is available at this time.

This system might appear to be complicated, involving detail labour and high cost. But this is erroneous. A systematic distribution of the entire burden over all the links of the chain of management simplifies matters to such an extent that, for deducing and tabulating the figures required for plotting the graph from the statistics supplied by the Mines Department and then plotting the same from even a dozen of big mines, not more than two intelligent clerks are needed. This system was evolved by the author in 1938 after he had experienced all the drawbacks of unsystematic management enumerated in the previous pages. For this, gratitude is expressed to the Burma Corporation, Ltd., Numtu, North Shan State, Upper Burma. Success in this line is entirely attributed to the little idea that the author obtained (while undergoing practical training there) of the system of management followed by the said concern, which employed thousands of labourers per shift in numerous departments. This has been given a thorough trial for the last several years with most satisfactory results.

It might be thought that, since some firms are doing well without the help of such scientific methods, these methods are a waste of time and energy. But it is not the profit that one earns through luck or its variants, but what should have been earned under these conditions through the application of systematic and scientific management that is the criterion of success. If the efficiency in such cases is lower than it should reasonably be, efficiency which could have been acquired through a little effort and exercise of common sense, such loss of efficiency, which can only be attributed to the carelessness or ignorance of the governing head, must be regarded as criminal. It is but natural for the subordinate staff to take things easy when the governing head is known to take things easy.

Under such unhealthy circumstances, the subordinate staff also gets more and more careless and the major part of them becomes thoroughly dishonest. This insidious and slow deterioration paralyzes the whole machinery and leads ultimately to a total collapse of the entire structure before the managing head comes to realize the danger.

It may be added at this point without the least exaggeration that this is a very common and unfortunate feature of the mica-mining industry of Bihar. This is evident from the disappearance with lock, stock, and barrel of a number of firms of substantial financial standing from the mica field within the last decade and a half. Out of those still in existence and apparently thriving some are struggling for existence, and if things continue as they are today, one should not be surprised to find them "in the soup" in the near future. As a matter of fact, it is the absence of such systematic management which is at the root of all the pother about "mica piracy."

When the concern is a limited-liability company, lack of scientific management is detrimental to the interest of the shareholders, a public body. And even if such a concern is owned by one single person such unhealthy conditions result in hopeless corruption of the staff and the labour force, leading to a most undesirable waste of time, energy in the shape of valuable fuel consumed by the mechanical equipment, and in most cases mica as well. Such losses are more of national character than personal. Moreover, the corruption referred to above affects the general structure of the social life and consequently the trade in general. For such undesirable deterioration leads ultimately to a disappearance of the sense of responsibility and the sense of duty and discipline from amongst the principal working factors, *viz.,* the staff and the labourers. Under such circumstances, the unduly low profit that is earned by a concern does not allow the payment of adequate wages to the labourers and staff and dividends to the shareholders.

Ultimately the demoralization affects the fabric of social life.

CHAPTER 7

Processing of Mica

Technically speaking, the term "manufactured" is not accurately applicable to the bulk of the mica exported from India. The processing of mica, as it is done today in India and in most other mica-producing countries, may be compared rather with the process of ore dressing, which concentrates the bulk of a metalliferous ore for the final separation of the valuable metal by smelting.

The treatment or processing of mica in India is confined mainly to the concentration or reduction of the bulk of the crude product of the mines to about 20 per cent of its original quantity by cleaving, dressing, sorting to different grades and qualities, and finally splitting the major part of it to a fine thickness of 1 mil or so, while the final application of the same to specified electrotechnical requirements is left for the consumers themselves to prepare, so that the so-called "manufactured" mica exported from India is largely in the nature of a raw material and cannot be rightly placed in the list of finished goods. Under these circumstances, the term "manufacturing" would be misapplied, and so this chapter has been captioned as "processing" of mica.

The processing of mica from beginning to end is entirely dependent on hand labour, and no power-driven machinery worthy of mention is used in a mica-processing factory. This peculiar feature of the industry serves to give special importance to the need for a large and stable labour force and adequate and careful supervision.

The entire process comprises a series of operations in which a piece of mica passes through a number of hands before it is finally packed for marketing. The waste factor is of such vital importance at every stage of the process that the greatest vigilance is required throughout. This aspect of the industry will be better understood after a careful study of the actual processing operations, which will be discussed in due course in this chapter. But, before proceeding further on the subject, it is necessary to have an idea of the various grades and qualities of mica and their prices.

TABLE 8

STANDARD GRADING OF MICA ACCORDING TO SIZES

Size	*Area of the largest rectangle of sound mica that can be cut out of a piece, sq. in.*
Over over extra extra special	100 and over
Over extra extra special	80 to below 100
Extra extra special	64 to below 80
Extra special	48 to below 64
Special	36 to below 48
No. 1	24 to below 36
No. 2	15 to below 24
No. 3	10 to below 15
No. 4	6 to below 10
No. 5	3 to below 6
No. 5½	2¼ to below 3
No. 6	1 to below 2¼
No. 7	Below 1

Table 8 describes the standard grading of mica, and Table 9 is the price list of the Joint Mica Mission, an Anglo-American official body that enjoyed a monopoly in the purchase of Indian mica for the Allied Nations during World War II. A careful study of Table 9 will acquaint the reader with the commercial names of the various qualities of mica and will convey an idea of the very wide difference between the prices of the lowest and the highest grades and qualities of mica, as well as between the lowest and the highest qualities of the same grade. Little has been said in this book about the last two qualities in Table 9, *viz.,* white and black spotted, because the former is produced by only one mine in Bihar, and the total Bihar production of the latter is extremely small, in comparison with that of Madras and Rajputana.

The price of mica depends on two variables, *viz.,* size or grade and

TABLE 9

JOINT MICA MISSION: LIST OF STANDARD PRICES FOR RUBY MICA,* RUPEES

Block Mica

	Clear & S.S.	*Fair stained*	*Good stained*	*Stained*	*Heavily stained*	*Densely stained*	*White*	*Black spotted*
100 up......	75/-	60/-	50/-	35/-	32/-	21/-	17/8/-	11/4/-
80/100....	65/-	50/-	40/-	30/-	28/-	18/-	15/-	10/4/-
Extra extra special....	54/-	40/-	30/-	25/-	15/-	13/4/-	....	9/-
Extra special	42/-	26/-	21/8/-	18/-	13/4/-	10/-	....	7/12/-
Special......	33/-	22/8/-	16/8/-	14/8/-	10/8/-	8/8/-	....	7/-
No. 1.......	28/8/-	19/-	14/-	11/8/-	8/-	7/4/-	8/-	6/-
No. 2.......	24/-	15/-	12/-	9/-	6/8/-	5/4/-	6/-	4/8/-
No. 3.......	21/-	12/8/-	9/8/-	7/-	4/10/-	3/8/-	5/-	3/8/-
No. 4.......	17/4/-	10/8/-	7/8/-	5/8/-	3/4/-	2/-	....	1/10/-
No. 5.......	12/-	6/8/-	4/8/-	3/-	1/14/-	....	....	-/13/-
No. 5½.....	6/10/-	4/12/-	3/8/-	2/-	1/4/-	....	....	-/8/-
No. 6.......	3/4/-	2/-	1/8/-	0/14/-	-/12/6	....	....	-/6/-

Condenser Films

	No. 6	*No. 5½*	*No. 5*	*No. 4*
First quality................	3/8/-	6/4/-	9/-	15/8/-
Second quality..............	2/8/-	4/10/-	7/-	10/8/-

Mica Splittings

	No. 6 third quality	*No. 6 second quality*	*No. 6 intermediate*	*No. 6 first quality*	*No. 5½*	*No. 5 first quality*	*No. 4½*	*No. 4*
Book-packed	.....	.....	......	1/5/-	2/-	3/8/-	4/8/-	5/4/-
Dusted loose	.....	.....	......	-/14/6	1/6/-	2/-	.....	3/6/-
Loose.......	-/5/2	-/7/6	-/10/6	-/12/6				

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* Prices are for mica delivered at Joint Mica Mission go-down, Kodarma or Giridih. First-quality condensers are to be split from fair stained block and second-quality from best of good stained block. Prices for films apply to all the usual recognized thicknesses. All block mica is to be of standard grading. Area of No. 5½ block, films or splittings to be not less than 2½ sq. in.

quality. The size or grade is determined by the area of the largest rectangle of sound material that can be cut out of a piece of mica, and the grading is done with the help of rectangular tin plates, commercially known as "formas." For a particular size or grade, there are a number of such formas comprising a set, all being of approximately the same area but of different lengths and breadths. Table 10 gives the sizes of all the formas belonging to a set up to No. 1 grade.

There is, however, one very important condition requiring the special attention of the sorter at the time of grading, and that is that the area covered by a particular forma must be thoroughly sound and that there should be no crack whatsoever within the area covered by such forma. It does not mean, however, that cracks outside the area covered by a forma are matters for indifference. In fact all cracks should be removed from a piece of mica of stained and better quality.

It is not possible to describe literally or diagrammatically how the quality of mica can be determined. The quality of mica is a joint function of hardness, flatness, and flawlessness (absence of conductive metallic stains, other inclusions, and pinholes as described on pages 47 to 48). But there is also the personal equation, the quality of mica being to an appreciable extent a matter of opinion. There is no formula governing the determination of a particular quality, and the entire subject is solely dependent on eye estimation, which can be acquired only by practice. The standard sample of a particular quality of a supplier consists of a number of pieces of mica representing the range between the maximum and the minimum defects that are tolerable from the commercial point of view for that quality. If a bulk predominates in the lowest variety of the range, it cannot possibly be considered as up to standard. This, in short, is an introduction to the grading of mica into sizes and qualities, and we may now proceed to a description of the actual processing operations.

The mined bulk of crude mica is roughly classified into two parts at the pit head, *viz.*, medium- and small-size crude. The bulk of medium-size crude includes mica of No. 5 and higher grades, while the small-size crude consists mainly of grades 6 and 7, with

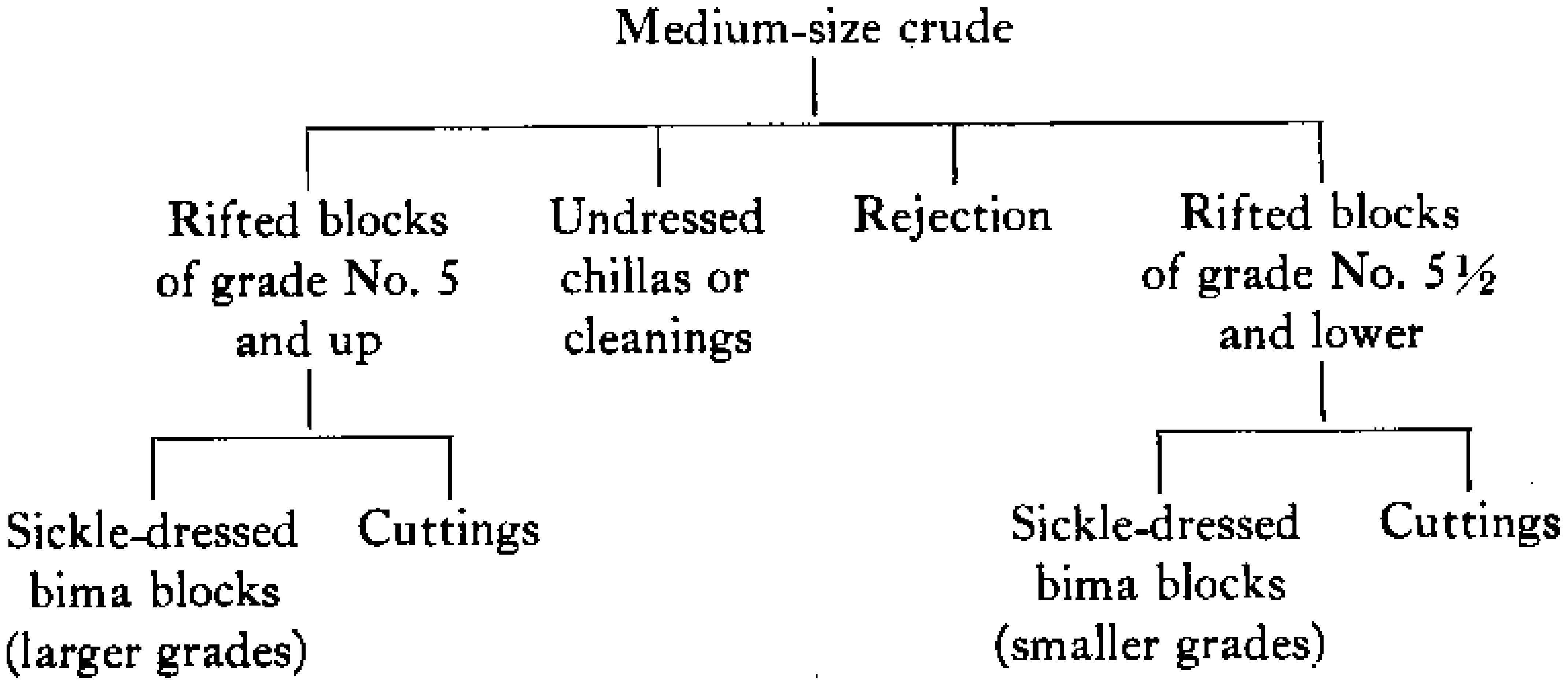
TABLE 10

POPULAR SIZES OF FORMAS BELONGING TO DIFFERENT GRADES

No. 1 grade (24 *sq. in.*)	*No. 2 grade* (15 *sq. in.*)	*No. 3 grade* (10 *sq. in.*)	*No. 4 grade* (6 *sq. in.*)	*No. 5 grade* (3 *sq. in.*)	*No. 5½ grade* (2½ *sq. in.*)	*No. 5½ grade* (2¼ *sq. in.*)	*No. 6 grade* (1 *sq. in.*)
10¾″ × 2¼″	8 17/32″ × 1¾″	6¾″ × 1½″	6″ × 1″	3″ × 1″	2½″ × 1″	2¼″ × 1″	1⅜″ × ¾″
9⅞″ × 2½″	7 17/32″ × 2″	5¾″ × 1¾″	5″ × 1 3/16″	2⅜″ × 1 5/16″	2″ × 1¼″	1 27/32″ × 1¼″	1″ × 1″
8¾″ × 2 25/32″	6 9/16″ × 2 9/32″	5″ × 2″	4 1/16″ × 1 17/32″	2″ × 1½″	1 19/32″ × 1 19/32″	1½″ × 1½″	
8″ × 3″	6″ × 2½″	4½″ × 2¼″	3 9/16″ × 1¾″	1 23/32″ × 1 23/32″			
7½″ × 3 7/32″	5½″ × 2¾″	4″ × 2½″	3″ × 2″				
7″ × 3½″	5″ × 3″	3¾″ × 2¾″	2 7/16″ × 2 7/16″				
6½″ × 3¾″	4¾″ × 3¼″	3½″ × 3″					
6″ × 4″	4 9/32″ × 3½″						
5¾″ × 4¼″	4″ × 3¾″						
5½″ × 4½″							
5¼″ × 4 23/32″							
4 29/32″ × 4 29/32″							

$1\frac{3}{16} \times \frac{9}{4} = 387$ 24 some proportion of grades 5 and 5½. This, however, is a very rough assortment. The S.D.B. obtained from the medium-size crude contains all grades of mica from the lowest to the highest. But in this case about 40 per cent of the bulk of S.D.B. produced is generally of No. 5 and higher grades. However, this separation of fairly large and sound pieces from the bulk of mined crude is done with the object of facilitating the handling by well-trained labour, so that the maximum recovery of larger grades is ensured. During this process of assortment, a considerable quantity, mainly consisting of small chips of mica, is rejected at the pit head and is known as "mine dump." From this pit-head rejection or mine dump, cheap splitting quality blocks, mostly for the manufacture of No. 6 second- and third-quality loose splittings, are recovered. After this assortment at the pit head, the sorted crude mica is brought to the factories for processing. Flow sheet 1 explains the preliminary treatment of the medium-size crude.

FLOW SHEET 1


Medium-size crude
Rifted blocks of grade No. 5 and up
Undressed chillas or cleanings
Rejection
Rifted blocks of grade No. 5½ and lower
Sickle-dressed bima blocks (larger grades)
Cuttings
Sickle-dressed bima blocks (smaller grades)
Cuttings

Referring to flow sheet 1, the sorted medium-size crude from the mines, which is locally called *Manjhari Kachha mal,* is rifted first. This process consists of splitting the crude books to block thickness, which varies from 8 mils to 30 mils, averaging about 20 mils. During this operation, the rifted pieces are kept as much on the thicker side as possible. After having cleaved a piece of block thickness from a thick crude book, the rifter extracts the maximum portion of sound mica from the piece, with the help of a knife. Such a cleaved piece may yield one or more pieces of useful mica, depending on the extent of cracks and defects that may be originally present in the piece. Much depends on this rifting operation, as far as the waste factor is concerned, for the slightest carelessness on the part of the rifter may lead to undergrading of a considerable percentage of the bulk, thereby reducing the value of the bulk to a great extent.

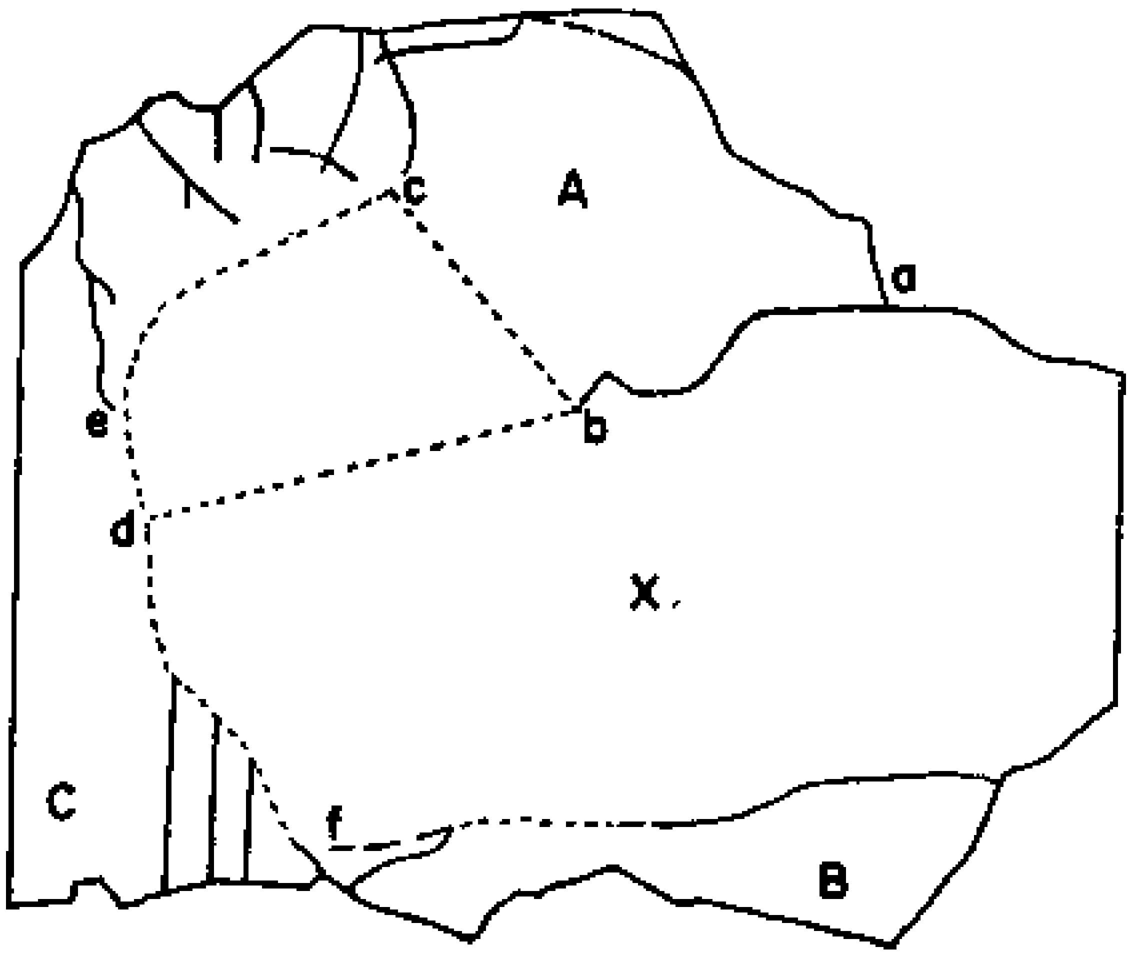


Fig. 42. A piece of crude mica showing how careless dressing may undervalue the piece.

This is explained better by Fig. 42. This sketch illustrates the danger of careless handling. To realize the largest area of sound mica, the rifter, after cutting the piece along the crack *ab*, should direct the knife in a curved direction, as shown by the broken lines *bc*, *ce*, *ed*, and *df*. If, instead, he should carelessly run his knife straight through the piece along the line *bd*, there is every chance of the piece *X* being undergraded. Even if it were not undergraded, the piece would lose a portion of the weight of the area represented by *bced*, which when added to piece *A* improves its grade. But the difference, in terms of value, between pieces *X* and *A* is so great that

1. In case piece *X* is undergraded, it loses a considerable value.
2. Even if it is not undergraded, the weight of the mica of the portion *bced*, being attached to a much lower grade, would lose a considerable portion of its value. Though the value of *A* is improved to some extent, the difference between loss and gain is definitely minus in most cases.

At the time of this rough rifting of the crude books, it is advisable to use the set of No. 5 formas, first, with a view to ensure the recovery of the maximum available proportion of No. 5 and up grade and, second, to separate the larger grades from the bulk, so that they may be carefully dressed by expert dressers, while the bulk of the smaller grades may be passed on to young lads of comparatively inferior caliber. This process of rifting is locally known as *Kholai*. As shown in flow sheet 1, some little production of chillas or cleanings (about 3 per cent) is unavoidably obtained during this operation. Care should be taken to keep this production of chillas as low as possible.

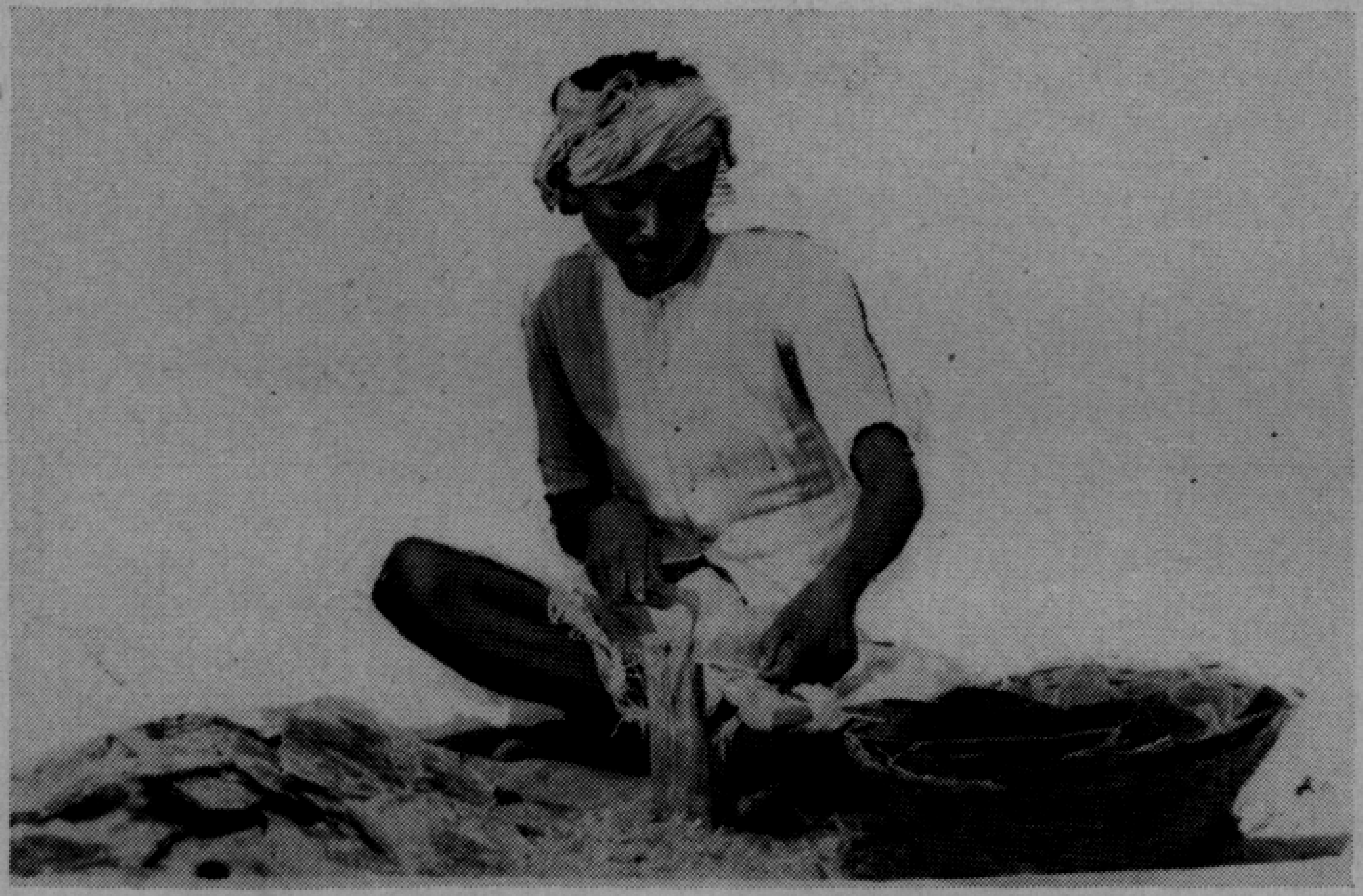


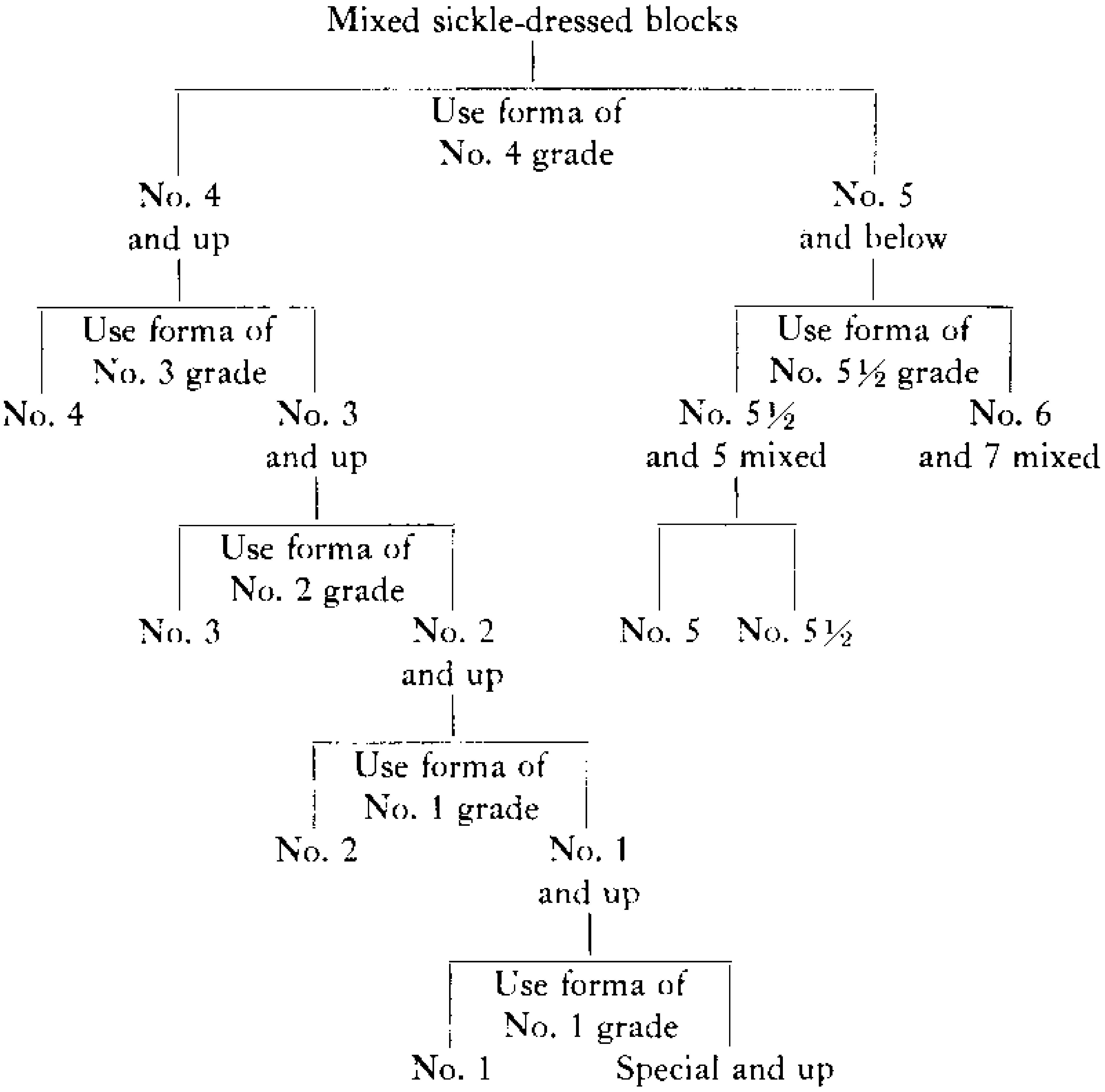
FIG. 43. Dressing mica with a sickle.

The rifted bulk is passed on to the sickle-dressing department, where the sides of all the pieces are further dressed and smoothed with the help of a sickle, as shown in Fig. 43. Sickle-dressed blocks are preferred to scissor-cut blocks, for the beveled edges produced by sickle dressing facilitate the splitting of blocks. This sickle-dressing operation is locally termed *hasoowa ḳatai*.

In some factories both these operations of rifting and sickle dressing are performed by the sickle dressers alone. This, however, is unwise, since with their limited intelligence and the speed required in dressing, the dressers cannot possibly be expected to give due attention to all the essential considerations.

After this process, the entire bulk becomes a mixture of all the grades and qualities, locally termed "bima mica," which is then sorted into the different grades with the help of formas, in the manner explained in flow sheet 2. This operation of grading is locally known as *number ḳarai.*

FLOW SHEET 2



After the sickle-trimmed mixed bima bulk has been sorted into different grades, the bulk of each grade or size remains a heterogeneous mixture of all qualities, from the lowest to the highest (in widely varying proportions, especially if the mixed bulk is a product of a number of different mines), which is then passed onto the *chhatai* department for quality classification.

This further assortment of a mixed-quality bulk of a particular grade of S.D.B. to standard qualities is one of the most difficult operations in a mica factory and is locally termed *chhatai* (the term *chhatai* literally means assortment). As has already been stated in the preceding pages, the quality classification of mica is solely dependent on eye estimation, hence it needs considerable experience, skill, and care, for, besides the sorting of a bulk to particular standards of quality, the final removal of defects and the cleaning of the pieces is done during this process.

Fig. 44. An ordinary table knife with end pointed by further grinding used for sorting mica.

The dressing of the S.D.B. is always to some extent rough, and during the sickle-dressing operation no appreciable attention is ever paid to the elimination of small cracks and some other defects, such as broken films, mild cross graining, buckling or corrugation on one side of a piece, etc. Even some fairly large cracks are sometimes carelessly overlooked by the rifters or sickle dressers. Hence, during this process of qualitative assortment, all such defects have to be eliminated and the rough sides have to be smoothed with the help of a knife, which is just an ordinary table knife with the end pointed by further grinding, as shown in Fig. 44.

A crack is eliminated by cutting a very small portion of the piece on both sides of the crack, in such a manner as to produce a V-shaped cut, as shown in Fig. 45, which represents a sickle-dressed piece of mica with cracks and the defect of cross graining on the shaded portion marked *A*. The rectangle drawn on the piece covers the minimum sound area required if the piece is to be included in a particular grade. Now, if, while trying to eliminate a crack, the sorter should carelessly run his knife into the rectangle even by 0.01 in., the piece becomes undergraded. For example, if while cutting the V as shown in the illustration, the sorter is not very careful, since the extremity of the crack *b* is very close to the side of the rectangle, the apex of the V cut may run into the rectangle and thereby undergrade the piece. In the event that there are a number of cracks on the same side of the piece, such as *a, b, c,* and *d* in Fig. 45, the knife must be run in a curved direction along the line *xz* in order to eliminate all the cracks, for more than two such V cuts of reasonable depths in grades up to No. 4 and three in the higher grades are generally objected to by the buyers; and while doing so, if the sorter is not very careful in manipulating the knife at the point *b* (inside end of crack) where the line *xz* runs very close to the side of the rectangle, he may cut a very slight portion of the side of the rectangle and undergrade the piece.

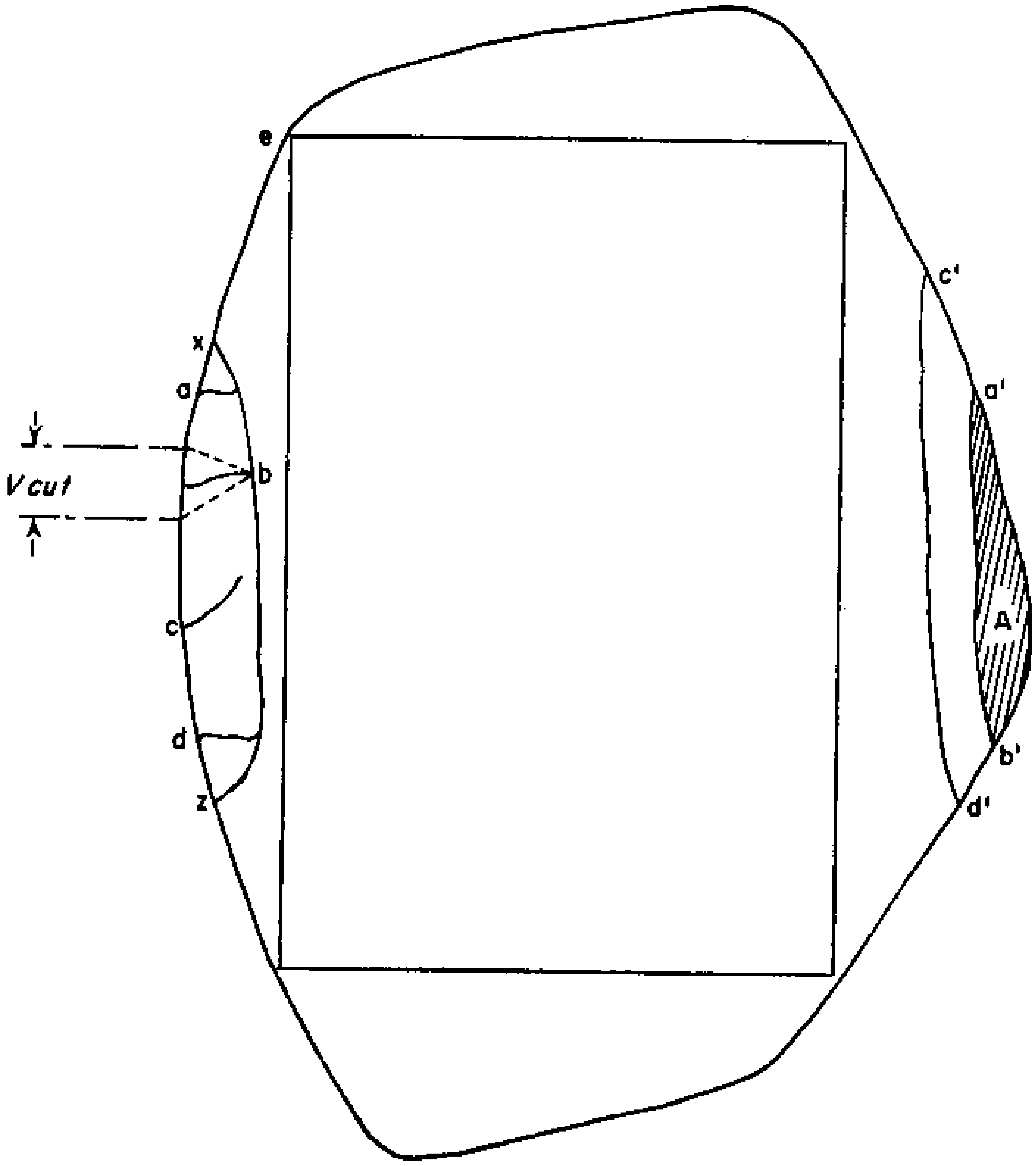


FIG. 45. Sketch explaining how to remove cracks and other defects frôm a piece of S.D.B. at the time of qualitative sorting.

The production of some undergrade pieces during this process is, however, unavoidable, for, besides the fact that a few pieces of the next lower grade are unconsciously included and because of the human element involved in the preliminary grading of bima S.D.B., there are always some pieces of the minimum size in the graded bulk of S.D.B., with cracks unfortunately located, which invariably render them undersize. For example, if the crack *b* in Fig. 45 had been slightly longer or located at point *e*, nothing could save the piece from being undergraded. However, apart from the unavoidable undergrading of some pieces, there is always some amount of undergrading caused by the carelessness of the sorter, which is most undesirable and has always to be avoided.

Again, if the sorter, while trying to remove the defective portion *A* (if this piece is estimated to be higher than the heavily stained quality), instead of running his knife along the line *a'b'*, runs it along the line *c'd'*, though the piece is not undergraded it unnecessarily loses a portion of its weight, which if left attached to it would have fetched some value.

In addition to the removal of the defects described above, any broken films on the surface of a piece should be taken off, but if in doing so the sorter carelessly removes a whole film, instead of removing the broken film only, the piece unnecessarily loses a portion of its weight.

A piece of mica may at first sight appear to be of a low quality, say stained, for example. But if the man handling it knows his job, he may improve the quality by taking a film off the piece or splitting it into two. This is of particular importance because in many cases it is found that defects like stains or mild cross graining, which lower the quality of a piece of block mica, do not run through the whole of its thickness. In some cases it is just at the top or below a thin film, and in other cases it is somewhere in the middle or so. But if, for lack of care, experience, or judgment, the sorter should split a book into two or take a film off and then find that the desired improvement has not been achieved, the bulk thus handled carelessly will have lost an appreciable percentage of its value through the unduly large production of chillas or cleanings.

The above explanation brings out clearly that careless handling of mica in this particular process results in three kinds of losses:

1. Undesirable undergrading.

2. Undesirable production of chillas.
3. Undesirable production of cuttings.

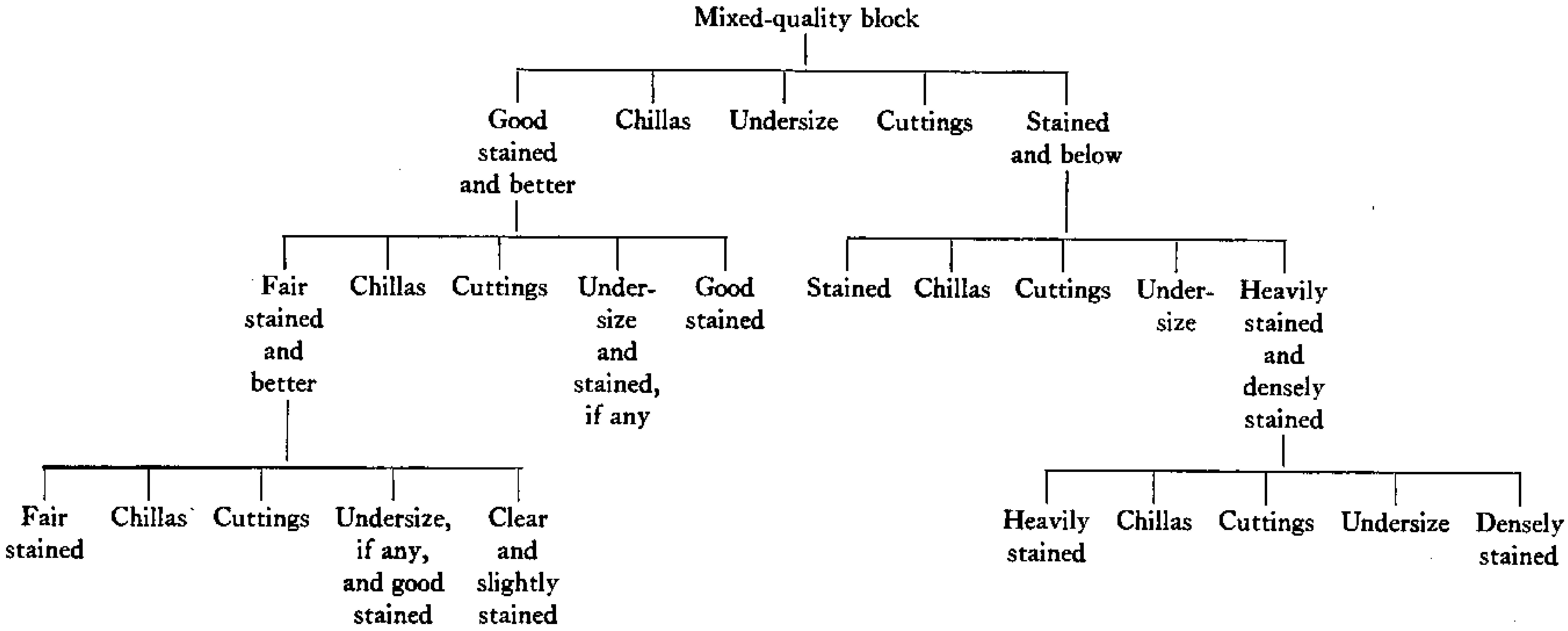
The loss in the first case, though appreciable, is not so vital as in the second case; for chillas thus produced bring much less value than even the undergraded pieces.

The last item of loss, that is, the careless production of cuttings, is the most vital one, for besides its adverse effect on grading, the value of the quantity produced as cuttings is lost for good. Hence, in view of the above, the maximum recovery of superior-quality mica from a mixed bulk of S.D.B., with the minimum production of chillas and cuttings and without an undesirable undergrading of an appreciable portion of the bulk, depends mostly on the skill of a sorter and the amount of care he takes in studying a piece for a reasonable time before doing anything to it. Thus this operation calls for the employment of well-trained and careful labour and very strict supervision.

In view of the complete dependence of this process on manual labour and eye estimation, the efficiency of the operation is generally very low and, added to this, if proper supervision is not ensured, the consequent disaster—it is no less—caused by the cumulative effect of all the factors of loss can well be imagined. Excessive waste, as a result of the above, is not uncommon in many factories in India, and it is an observed fact that the quality assortment of practically the same bulk in two different factories at times makes a difference of even 20 per cent in the recovery of the ultimate value. Flow sheet 3 describes the quality assortment of mica, stage by stage, and shows how at each stage some production of chillas and undersize is usually obtained.

As shown in flow sheet 3, after the classification of the bulk into two parts, *viz.*, good stained and better, and stained and below, when fair stained and better quality blocks are separated from the good stained blocks in the second stage, the production of chillas and undersize that is obtained is less than that in the first stage, which further decreases in the third stage. In the second and third stages, we find some production of the next lower quality with the undersize. These are border-line pieces which, being doubtful, are included in the bulk of the next higher quality by the previous-

FLOW SHEET 3


Mixed-quality block
Good stained and better
Chillas
Undersize
Cuttings
Stained and below
Fair stained and better
Chillas
Cuttings
Undersize and stained, if any
Good stained
Stained
Chillas
Cuttings
Undersize
Heavily stained and densely stained
Fair stained
Chillas
Cuttings
Undersize, if any, and good stained
Clear and slightly stained
Heavily stained
Chillas
Cuttings
Undersize
Densely stained

stage sorter. The elimination of such pieces is left to the judgment of the second man, who does the subsequent assortment.

Flow sheet 3 refers only to the quality sorting of No. 4 and larger grades, with the exception that, in the case of No. 4, a certain production of block mica for the manufacture of "book-packed splittings,"* locally known as "book blocks," is obtained. The production of book blocks in No. 4 grade is obtained chiefly from thick chillas, inferior quality soft stained or heavily silver stained blocks, and superior heavily stained blocks with vegetable stains, which can be eliminated by rejecting two or three films after a book has been split. This is because, in the presence of an active demand for No. 4 stained quality blocks, the available price of No. 4 book-packed splittings may not allow a profitable use of the same for its manufacture.

In the case of grades 3 and larger, the production of thick chillas is sold as thin blocks and generally at prices slightly higher than those of the heavily stained quality of the respective grades.

These large-size thick chillas are also often used along with stained quality blocks of their respective grades for the manufacture of Nos. 3, 2, and 1 book-form splittings (generally split 0.0005 to 0.00075 in.) mostly against European demand.

The quality sorting of the lower grades like 5 and 5½ is done a bit differently, since there is always a heavy demand for book-packed splittings of these grades at attractive prices, which invariably allow a reasonable manufacturing profit over the price of No. 5 stained quality block mica. Moreover, there is seldom an appreciable demand for No. 5 stained blocks, and so one does not bother at all about their production. Practically the entire available bulk of stained quality is sorted out of the original mixed bulk along with the preparation of book-quality blocks. Added to this is the freedom one gets in sorting book-quality blocks with regard to thickness. For when selling a particular bulk in block form, one must restrict oneself to a minimum thickness of 8 mils. But, in the case of book-packed splittings, if the bulk contains a reasonable percentage of books consisting of at least four sound films, it is acceptable to the consumers. This allows a sorter a considerable latitude in cleaving heavily stained blocks with vegetable and other stains in a few films, which can be removed after splitting such blocks to 4 to 8 mils thickness. A mixture of these thin blocks and of the stained quality blocks produces a perfectly sound bulk of book blocks of the permissible average thickness.

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* This is an American term, and an English equivalent of this is "book-form splittings."

The only departure from this general rule, with regard to the profitable use of No. 5 stained for the manufacture of book-packed splittings, was during the Joint Mica Mission days, when the difference of price between stained quality mica and book-packed splittings of No. 5 and lower grades did not allow a profitable use of the former for the manufacture of the latter. Table 11, which shows the prices of Nos. 5 and 5½ book-packed splittings and those of the stained blocks of the same grades, basically fixed by the Joint Mica Mission in 1942, as well as those fixed by the United Kingdom government in November, 1946, for the sale of war surplus stocks of mica, explains this clearly.

TABLE 11

PRICE OF NOS. 5 AND 5½ BOOK-PACKED SPLITTINGS AND STAINED BLOCKS, RUPEES

Number	1942 *prices*		1946 *prices*	
	Book-packed splittings	*Stained blocks*	*Book-packed splittings*	*Stained blocks*
No. 5........	3/8/-	3/-/-	10/3/6	4/13/4
No. 5½......	2/-/-	2/-/-	5/1/9	4/-/-

It is as a result of this discrepancy that huge quantities of stained mica in Nos. 5 and 5½ were not converted into splittings but were sold to the Joint Mica Mission as blocks, which again were left as surplus in the hands of the United Kingdom government after World War II. A reference to Appendix 3 will show that, since these lower grades in stained quality blocks generally find no appreciable use in block form, it has been thought desirable to ship them back to India for conversion into splittings. The reason for this unbalanced price fixation, which was to the advantage neither of India nor of the consumers' countries, either during the war or after the war, is however unknown.

Flow sheet 4 explains how the quality assortment of grades 5 and 5½ is done.

In the case of the mixed bulk of grades 6 and 7, the quality sorting is done practically in the same manner as in the case of grades 4 and up blocks, for in this case there is always a demand for No. 6 stained blocks. Besides, there is a fairly regular demand for stained quality mica selected to cut 1-in.-diameter circles. Hence, the preparation of stained and better blocks, in the case of grades 6 and 7, is done from the pieces selected to cut the 1-in.-diameter circle and not from 1 sq. in. The only difference between the sorting of these grades and that of larger grades is that the balance left, after the separation of stained and better blocks from the bulk, has further to be sorted in a different manner, according to the specifications of the different sizes of No. 6 splittings in current demand, which quantitatively constitute the most substantial part of the Indian mica trade.

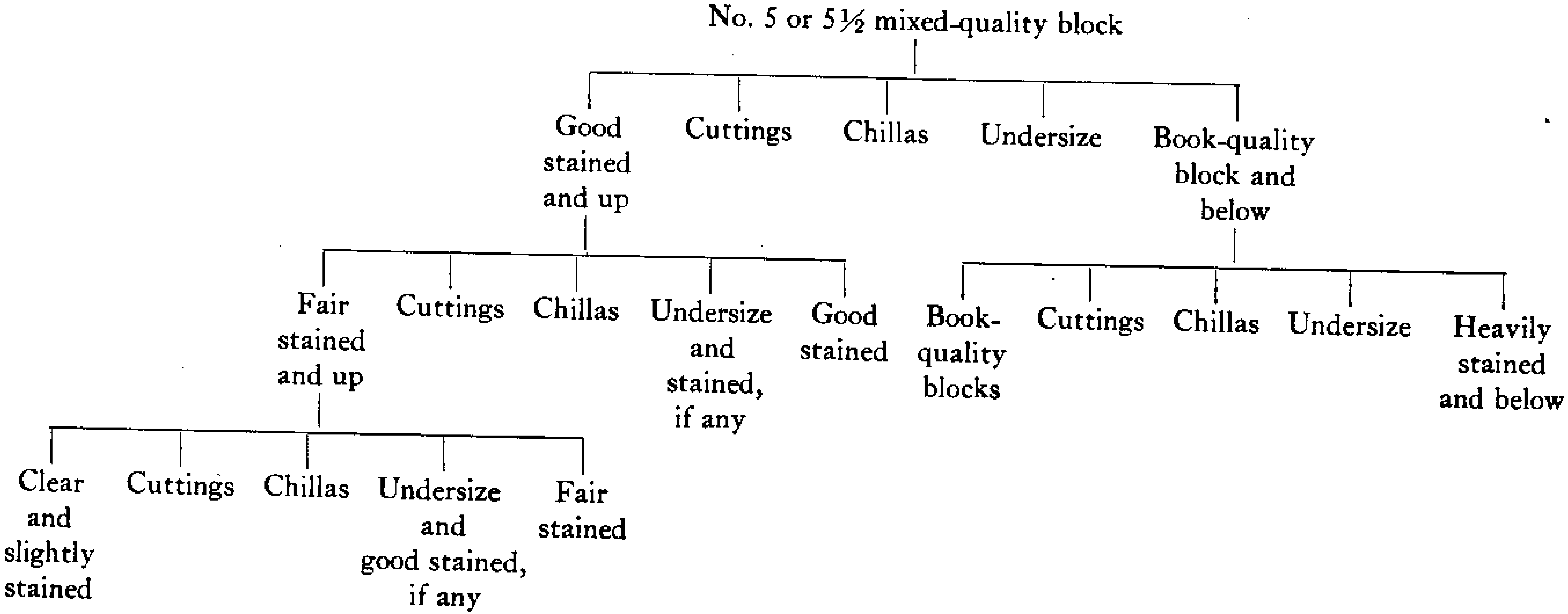
Flow sheet 5 explains the quality assortment of No. 6 and No. 7 blocks.

A further assortment of stained and better quality blocks is done in the usual way, while from the rejection, as has been explained in flow sheet 5, first- and second-quality loose splitting blocks are sorted. From the rejections at this stage, third-quality loose splitting blocks are recovered by sieving this bulk of rejections through ¾-in. mesh. At times, when the product of a mine producing superior quality mica is being handled, condenser-quality chillas or thin blocks are also recovered from the bulk of No. 6 first-quality loose splitting blocks.

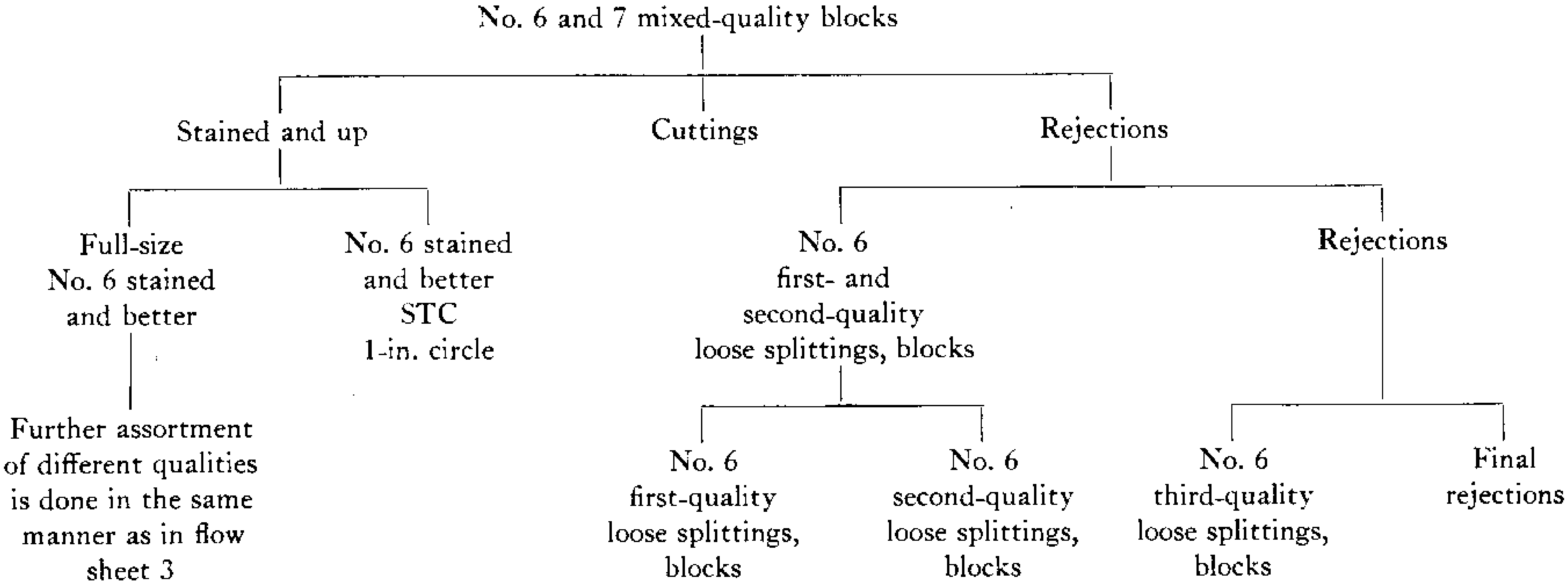
When there is an active demand for No. 6 book-form splittings, No. 6 stained, heavily silver stained, and/or superior heavily stained blocks are used for the manufacture of the same.

Besides the production of grades 6 and 7, there is always an

FLOW SHEET 4


No. 5 or 5½ mixed-quality block
Good stained and up
Cuttings
Chillas
Undersize
Book-quality block and below
Fair stained and up
Cuttings
Chillas
Undersize and stained, if any
Good stained
Book-quality blocks
Cuttings
Chillas
Undersize
Heavily stained and below
Clear and slightly stained
Cuttings
Chillas
Undersize and good stained, if any
Fair stained

FLOW SHEET 5

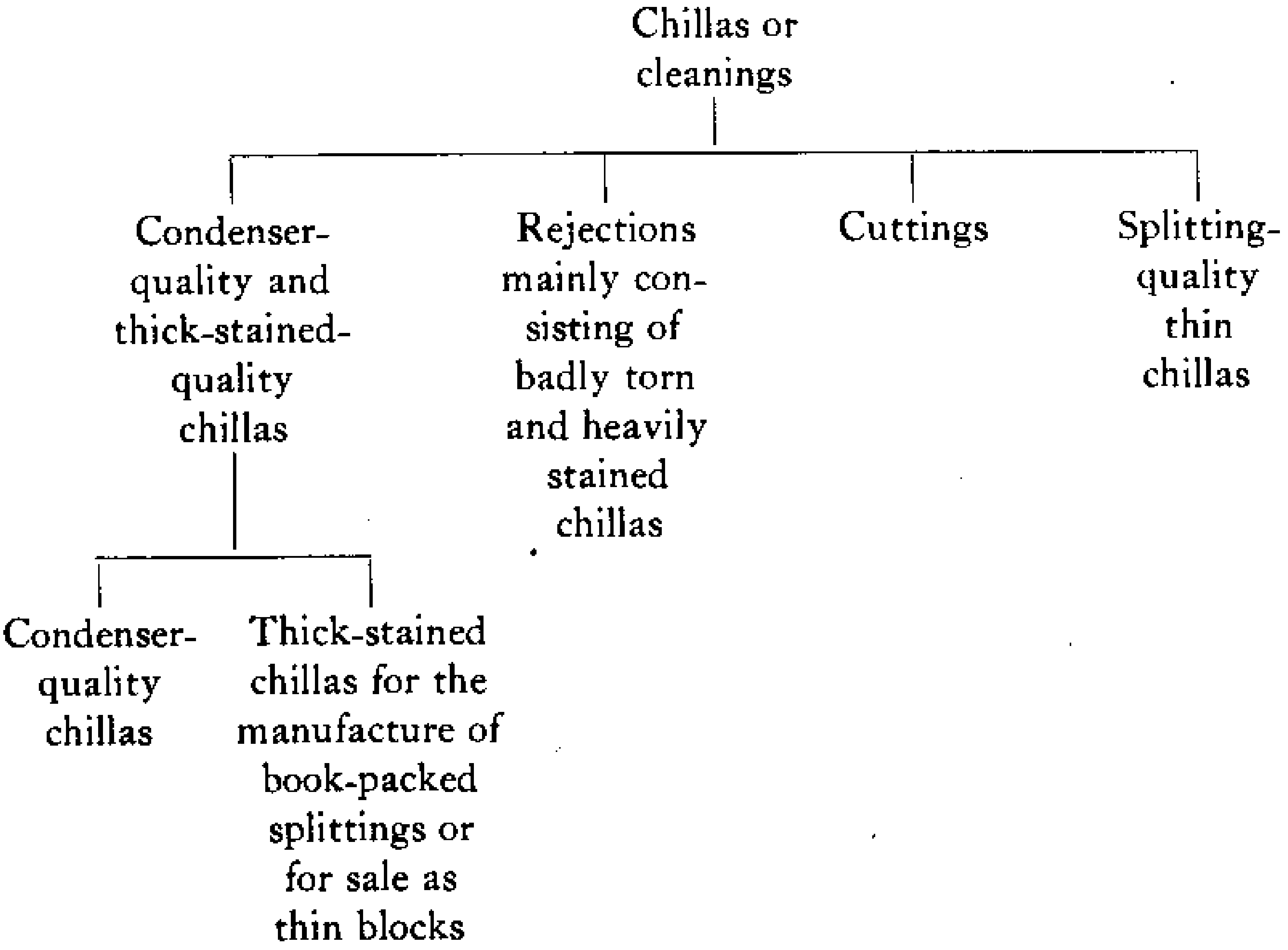

No. 6 and 7 mixed-quality blocks
Stained and up
Cuttings
Rejections
Full-size No. 6 stained and better
No. 6 stained and better STC 1-in. circle
No. 6 first- and second-quality loose splittings, blocks
Rejections
Further assortment of different qualities is done in the same manner as in flow sheet 3
No. 6 first-quality loose splittings, blocks
No. 6 second-quality loose splittings, blocks
No. 6 third-quality loose splittings, blocks
Final rejections

appreciable production of inferior small-size blocks obtained from both mines and factory dumps. In case there is a heavy demand for No. 6 third-quality loose splittings, the production of such cheap blocks from dumps is enhanced to a very great extent, as was the case in 1937. Usually such inferior blocks contribute substantially to the production of No. 6 third-quality loose splittings.

There are occasional demands for inferior splittings popularly known as "cheap loose." Such cheap splittings are generally manufactured from comparatively sound pieces salvaged from undressed factory waste.

Throughout the entire process, there is a predominance in production of chillas or cleanings and as a consequence the total production of chillas in a mica factory is considerable. Such chillas are first sorted according to different sizes, in the same manner as in the case of block mica, after which the quality sorting of chillas, locally known as *chilla chhatai,* is done as shown in flow sheet 6.

FLOW SHEET 6


Chillas or cleanings
Condenser-quality and thick-stained-quality chillas
Rejections mainly consisting of badly torn and heavily stained chillas
Cuttings
Splitting-quality thin chillas
Condenser-quality chillas
Thick-stained chillas for the manufacture of book-packed splittings or for sale as thin blocks

Let us now pass on to a discussion of the so-called "manufacturing" part of the trade. Strictly speaking, mica splittings, condenser films, wrappers, etc., as exported from India, cannot be classified as manufactured goods. At best, one may go to the extent of placing them in the category of semimanufactured materials, for all loose and book-packed splittings are used in the manufacture of various types of micanite or built-up mica, mica tapes, mica cloth, mica paper, etc. In the case of wrapper splittings, as well as condenser films, the bulk shipped from India has subsequently to be cut to specified sizes. This ultimate conversion of the entire quantity to usable shapes and sizes rests with consumer countries alone, and the waste factor involved in the final application is as high as 50 per cent of the total bulk shipped from India in most cases.

It is as a result of this factor that the tariff imposed by the United States government on the import of mica varies with the different forms in which mica is imported from India and other countries. Table 12 gives details of the different rates of import duty.

TABLE 12

UNITED STATES DUTY ON IMPORTED MICA*

Description	*Duty*
Mica, unmanufactured:	
Valued at not above 15 cents per lb.	4 cents per lb.
Valued at above 15 cents per lb.	2 cents per lb. and 15% ad val.
Mica, cut or stamped to dimensions, shape, or form	40%
Films, or splittings, not cut or stamped to dimensions:	
Not above 0.0012 in. in thickness	12½% ad val.
Over 0.0012 in. in thickness	20% ad val.
Films and splittings cut or stamped to dimensions	22½% ad val.
Mica plates and built-up mica	25% ad val.
All manufactures of which mica is the component material of chief value	25% ad val.
Untrimmed phlogopite mica from which no rectangular piece exceeding 1 by 2 in. in size may be cut	5% ad val.
Mica waste and scrap valued at more than 5 cents per lb.	15% ad val.
Mica, ground or pulverized	15% ad val.

* These rates have been taken from Schedule XX, Modified Rates of Duty, Most-favored-nation Tariff, Bureau of Customs, Treasury Department, U. S. Government.

Because of the acute labour shortage that occurred during the war in the United Kingdom and the United States, considerable quantities of manufactured mica, in the shape of cut wrappers and condenser plates of various specified sizes and thicknesses, were purchased from the Indian market by the Joint Mica Mission. But unfortunately, for reasons unknown to the Indian mica trade, these operations were suddenly ordered to be discontinued by the Joint Mica Mission, after only a year or so.

Table 13 gives the specifications of the various sizes of cut condenser plates purchased by the Joint Mica Mission, and Table 14 gives those for cut wrapper splittings, with their respective prices. A study of these tables will help the reader to appreciate the remarkable difference between the so-called "manufacturing" done in India and the final manufacturing usually done in foreign countries. These cut sizes were manufactured in India with the help of specially designed guillotine knives operated by hand (Fig. 46), with satisfactory results; and the prices may appear to be very attractive for the respective sizes, in comparison with those paid for uncut first- and second-quality condenser films, or stained blocks in

TABLE 13

SPECIFICATIONS FOR CUT CONDENSER PLATES PURCHASED BY JOINT MICA MISSION

Size	*Thickness, mils*	*Price per lb., Rs.*
1. 1½" × 2"	1½–3	35/–
2. 1.37" × 1.37"	¾–1¼	32/–
3. 1⅛" × 1⅛"	2 –3	18/–
4. ⅞" × 1⅛"	2 –3	18/–
5. 11/16" × 63/64"	1¼–2¼	18/–
6. 11/16" × 63/64"	2¾–3¼	18/–
7. 1¼" × 1¼"	1¼–2	27/8/–
8. 1" × 11/16"	1½–2	21/–
9. 1⅜" × 1⅛"	1½–2	25/–
10. 1½" × 1½"	1¾–2¾	27/8/–
11. 1⅝" × 1⅜"	1.7–2.2	27/8/–
12. 1⅝" × 1⅜"	2.7–3.2	27/8/–

the case of wrappers. But considering the labour and waste factor involved, the prices paid for cut sizes did not allow more than a barely reasonable manufacturing profit.

TABLE 14

SPECIFICATIONS FOR CUT WRAPPERS

Size	*Quality*	*Thickness*	*Price per lb., Rs.*
1. 1½″ × 3″ and up........	Stained	1–1½ mils	25/–
2. 1.615″ × 2½″ and up....	Stained	1–1½ mils	25/–
3. 1⅝″ × 3″ and up........	Stained	1–1½ mils	25/–
4. 2″ × 3″ and up..........	Stained	1–1½ mils	27/8/–
5. 1¾″ × 3¼″ to 5″.......	Stained	Random	20/–
6. 1¾″ × 3¼″ to 5″.......	Heavily stained	Random	15/–

A couple of decades ago, the punching of mica to various shapes and sizes used to be done on quite an extensive scale in India; but this business is practically dead now, though the demand for punched washers and disks of various sizes has been quite active since 1946. Figure 47 shows some of these punched mica products.

Returning now to the main subject, it may be said, in brief, that after a bulk has been sorted according to its different qualities, some items are sold directly as block mica or sheet mica and some are further processed according to current trade specifications or specifications of the consumers. This further processing consists mostly of splitting mica to finer thicknesses with the help of a special type of double-edged knife pointed at the end as shown in Fig. 48. Generally the split products of mica have the following characteristics:

1. Average grading.
2. Softness and thinness of splittings.
3. Average soundness, meaning absence of ragged or torn films beyond a certain specified or unavoidable limit.
4. Cleanliness of the bulk and its freedom from metallic stains or mud stains.

5. Regularity of thickness, meaning uniformity in the thickness of individual splitting.

Carelessly manufactured splittings are often found to be lacking in this most important characteristic, regularity of thickness. If a small portion of a particular piece of splitting, of, say, ¾-mil thickness, shows a thickness of about 1½ mils, then the thickness of such splittings is considered to be irregular. The thick end, or "heavy end" as it is commercially called, is a very serious defect and is vehemently detested by the consumers, for it causes considerable hindrance in the manufacture of micanite. In the larger grades, or even in the

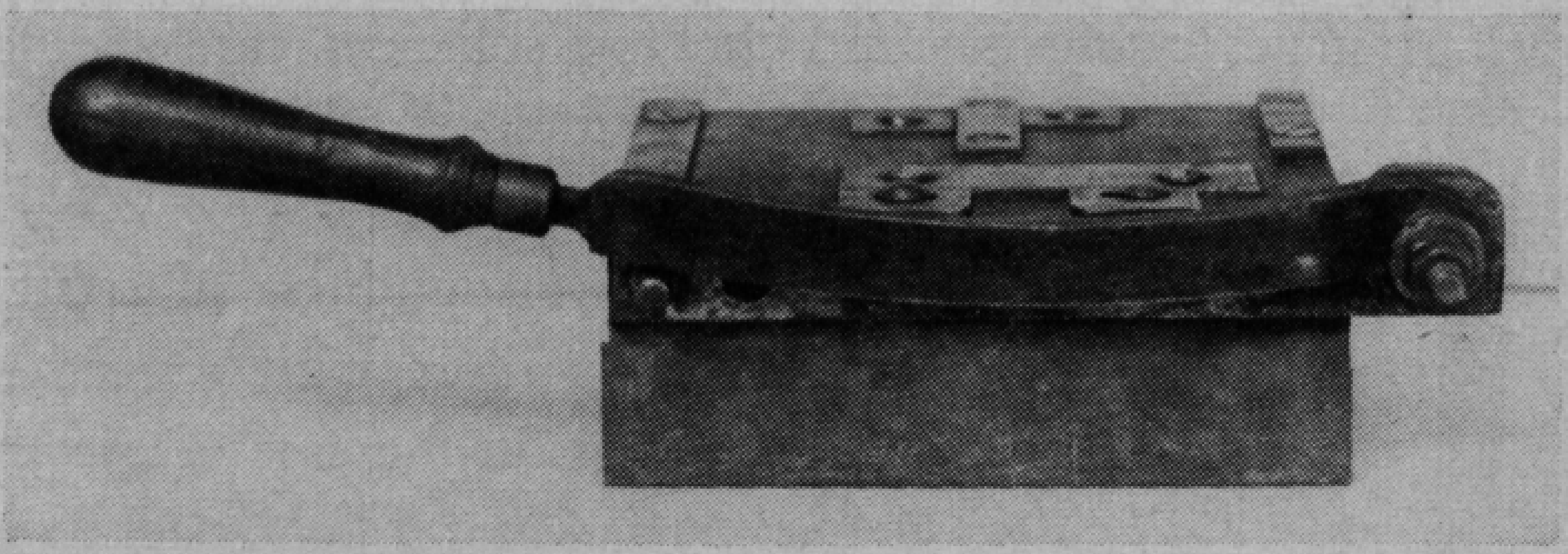


Fig. 46. Guillotine knife for cutting mica condenser and wrapper plates.

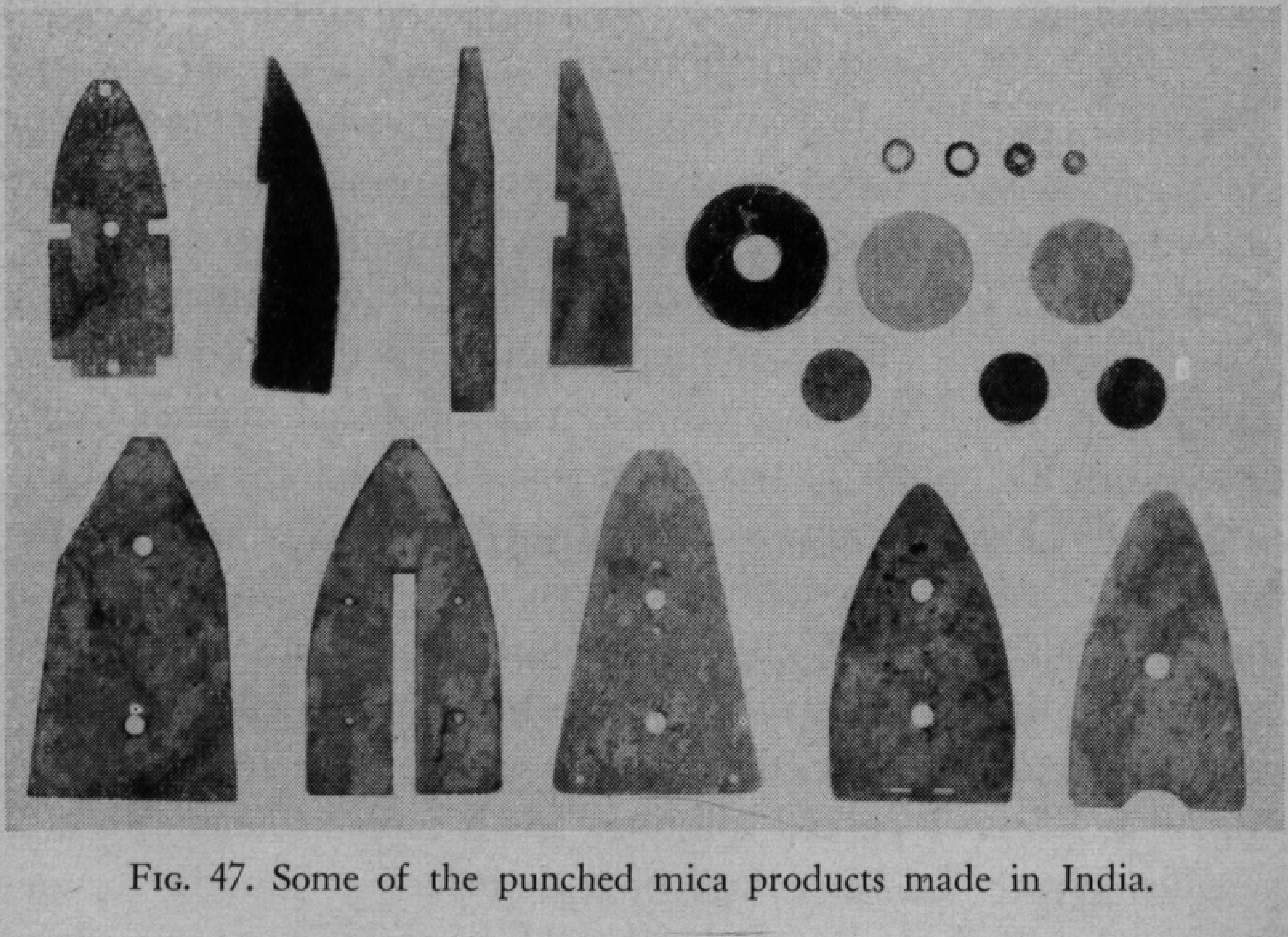


Fig. 47. Some of the punched mica products made in India.

case of No. 6 first-quality loose splittings, this defect may be avoided almost completely with careful supervision. But in the case of the cheaper varieties of splittings, such as No. 6 second- and third-quality or inferior loose splittings, the presence of a certain proportion of splittings with heavy ends is practically unavoidable, though at various stages of sieving and packing sufficient care should be taken to eliminate them to the best of one's ability.

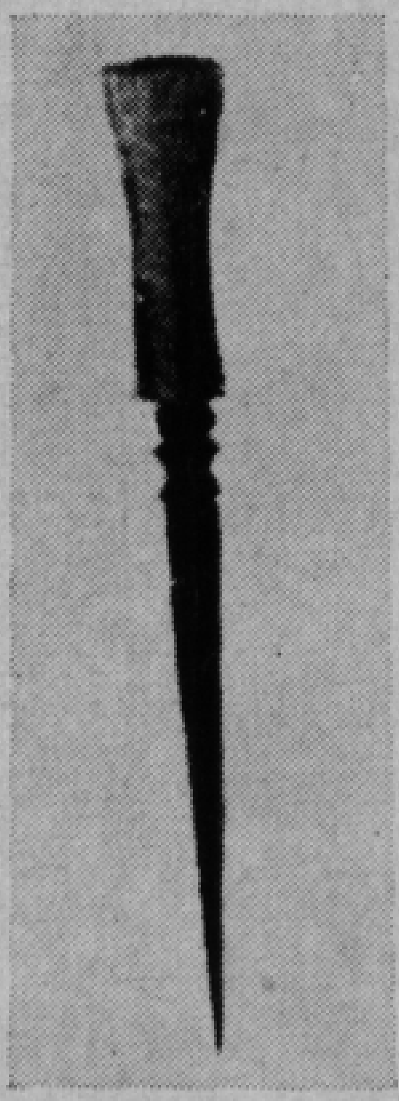


FIG. 48. A special type of double-edged knife pointed at the end, for splitting mica to finer thickness.

Now coming to the soundness of splittings, the presence of some films with ragged sides is unavoidable, though in the case of the larger grades, such as Nos. 4 and 5 book-packed splittings, care should be taken to avoid the inclusion of ragged and torn films, as far as is practicable at the time of packing. In the case of book-packed splittings, the bulk of a carefully finished product should not generally contain more than 4 to 5 per cent of moderately ragged and torn films.

In view of the present much-enhanced labour wages, it is no longer possible to manufacture Nos. 5½ and 6 book-form splittings in the factory. These are now generally manufactured by "home splitters." Splittings thus produced are not as good as can be produced in the factory, especially with respect to the percentage of torn and ragged films in the bulk. Moreover, on account of the smallness of the size, the passing and packing operations are generally much slower than in the case of larger grade splittings. Consequently, the cost of final finishing of these products has risen so high that the elimination of ragged and torn films to the extent it can be done in the case of Nos. 4 and 5 book-packed splittings has become economically impossible. Hence the percentage of such defective films in the deliveries of such lower grades of book-form splittings varies from about 10 to 15 per cent, depending upon the available price.

Loose-packed splittings of all grades are generally manufactured from chillas and/or less sound blocks which cannot be used for the manufacture of book-packed splittings. The percentage of such torn and ragged films in loose splittings is naturally much higher than in the case of book-packed splittings. In fact, this percentage is inversely proportional to the grade and the available price of these splittings.

Except for a few occasional light vegetable stains, the presence of metallic stains or mud stains is intolerable in any type of splittings, although in the case of No. 6 splittings the inclusion of some films with metallic specks is unavoidable. Table 15 gives the standard specifications for splittings prescribed by National Electrical Manufacturers Association (N.E.M.A.) of the United States.

The sizes for the standard commercial gradings, as described in Table 15, differ considerably from those described in Table 8. In the case of No. 5 first-quality book-packed splittings the grade is often split into two parts as Nos. 4½ and 5, the sizes being 3 to less than 4, or 4½ sq. in. for No. 5 and 4, or 4½ to 5⅞ sq. in. for No. 4½. Most American customers generally use these two grades, while in the European countries standard No. 5 commercial grading (3 to 5⅞ sq. in.) is usually preferred.

Let us now pass on to a discussion of the process of manufacture of the various types of splittings detailed in the foregoing pages.

Loose Splittings

As already explained, all types of loose splittings are generally prepared from lower quality blocks and chillas that cannot be sold as block mica or used for the manufacture of condenser films or book-form splittings.

The preparation of these loose splittings as well as Nos. 5½ and 6 book-packed splittings forms a sort of cottage industry in the district of Hazaribagh, Province of Bihar, employing more than 1½ lacs (150,000) of labourers.

These splittings are manufactured through contractors, or through the manufacturers' own distributing centers, commercially known as "home splitting centers," set up in different villages in the district of Hazaribagh. Mica from the main factories is sent to

TABLE 15

STANDARD CLASSIFICATION OF MUSCOVITE MICA SPLITTINGS (N.E.M.A.)

N.E.M.A. grade	*Form*	*Size* †	*Thickness per 10 splittings, in.*	*Remarks*
AA........	No. 4 first quality Book form (1) * Loose with powder (2) *	6 up to 10 sq. in. Minimum dimension of usable rectangle 1 ½ in.	0.006–0.009 0.007–0.010	(1) Splittings must be sound, clean, free of mineral spots and substantially ‡ free of vegetable stains, and split to specified thickness without thick edges. Edges must be clean cut
A.........	No. 5 first quality Book form (1) * Loose with powder (2) * Loose (2) *	3 up to 6 sq. in. Minimum dimension of usable rectangle 1 in.	0.006–0.009 0.007–0.010 0.007–0.010	
B.........	No. 5 ½ first quality Book form (1) * Loose with powder (2) * Loose (2) *	1 ½ up to 3 sq. in. Minimum dimension of usable rectangle ⅞ in.	0.006–0.009 0.007–0.010 0.007–0.010	
C.........	No. 5 ½ second quality Loose with powder (2) * Loose (2) *	At least 75 per cent of splittings to be 1 ½ up to 3 sq. in. with a minimum dimension of the usable rectangle of ⅞ in., balance to be at least 1 up to 1 ½ sq. in.	0.007–0.010 0.007–0.010	(2) Same as (1) except that edges may be slightly irregular in shape and splittings may contain not more than 5 per cent slightly weathered or vegetable-stained splittings. No mineral stains allowable
D.........	No. 6 first quality Loose with powder (2) * Loose (2) *	At least 60 per cent of splittings to be 1 up to 1 ½ sq. in., balance to pass over screen with ¾-in. square openings	0.007–0.010 0.007–0.010	
E.........	No. 6 second quality Loose (2) *	At least 50 per cent of splittings to be 1 up to 1 ½ sq. in., balance to pass over screen with ½-in. square openings	0.007–0.011	
F.........	No. 6 third quality Loose (3) *	Splittings shall be of minimum area of ¾ sq. in and should pass over screen with ½-in. square openings	0.007–0.012	(3) Splittings must be sound, clean and split to specified thickness, but they may contain not more than 7 ½ per cent slightly weathered or vegetable-stained splittings. No mineral stains allowable

* The numbers in parentheses refer to the correspondingly numbered remarks.

† "Up to" means "not including." Splittings shall not be all of the minimum size but shall contain a fair proportion of sizes throughout the range.

‡ Stained splittings shall not average more than 1 in 500 throughout a case.

Grade areas. The surface areas listed above do not refer to the total areas but to the rectangular sizes that each grade should produce. For example, these centers, from which the random-thickness blocks and chillas are issued to the labourers in the villages, who are locally known as "home splitters." The mica is taken by these home splitters to their homes near by, where they manufacture splittings during their leisure hours. After completing the manufacture of the entire bulk, they bring it back to the distributing centers, deposit the splittings, and take fresh issues of blocks.

To check excessive waste and also dishonesty, the percentage of yield is fixed; and a splitter must bring back to the distributing center a fixed quantity of manufactured splittings against the quantity of blocks received. For example, if 2 lb. of blocks is issued to a home splitter and the percentage fixed is 75, then he is to bring back to the distributing center 1½ lb. of splittings or else he is penalized. When a certain quantity of bulk is thus manufactured, it is brought to the main factory from these centers, where it undergoes a further screening and quality test.

First, it is subjected to a careful visual and hand test for ascertaining the average grading, softness, soundness, etc., of the bulk, and then, in the case of Nos. 5½ and 6 loose splittings, samples are collected from all the baskets belonging to a lot. The bulk sample thus collected is then sieved through a particular mesh to ascertain the average percentage of rejection in screening. In case the rejection exceeds the permitted limits or the average bulk is undesirably ragged or thick, the person in charge of the distributing center or the contractor is taken to task.

This particular operation of manufacturing these splittings is so slow that it is an economic impossibility to get the work done by factory labour. A splitter working in a factory must be paid at least 15 annas a day, and in case he is required to do this job in the factory, he will split at the best only ½ lb. of No. 6 first-quality loose splittings in one shift, whereas the same has to be sold at about Rs.1/12/- to Rs.1/14/- a pound f.o.b. Calcutta, at the highest. In the case of second- and third-quality loose splittings, the production will be still less. Under these circumstances, it becomes understandable without further explanation how important and valuable are the contributions of these native villagers in making possible the production of a large volume of splittings at a cost cheap enough to permit its sale at prices that otherwise would be completely unprofitable.

After the manufacture of these splittings, the bulk is screened, as shown in Fig. 49, over the different meshes fixed for the different grades of splittings, before final packing. The waste factor in sieving splittings should vary from 10 to 20 per cent according to different grades. The size of mesh used for different grades of splittings is given below.

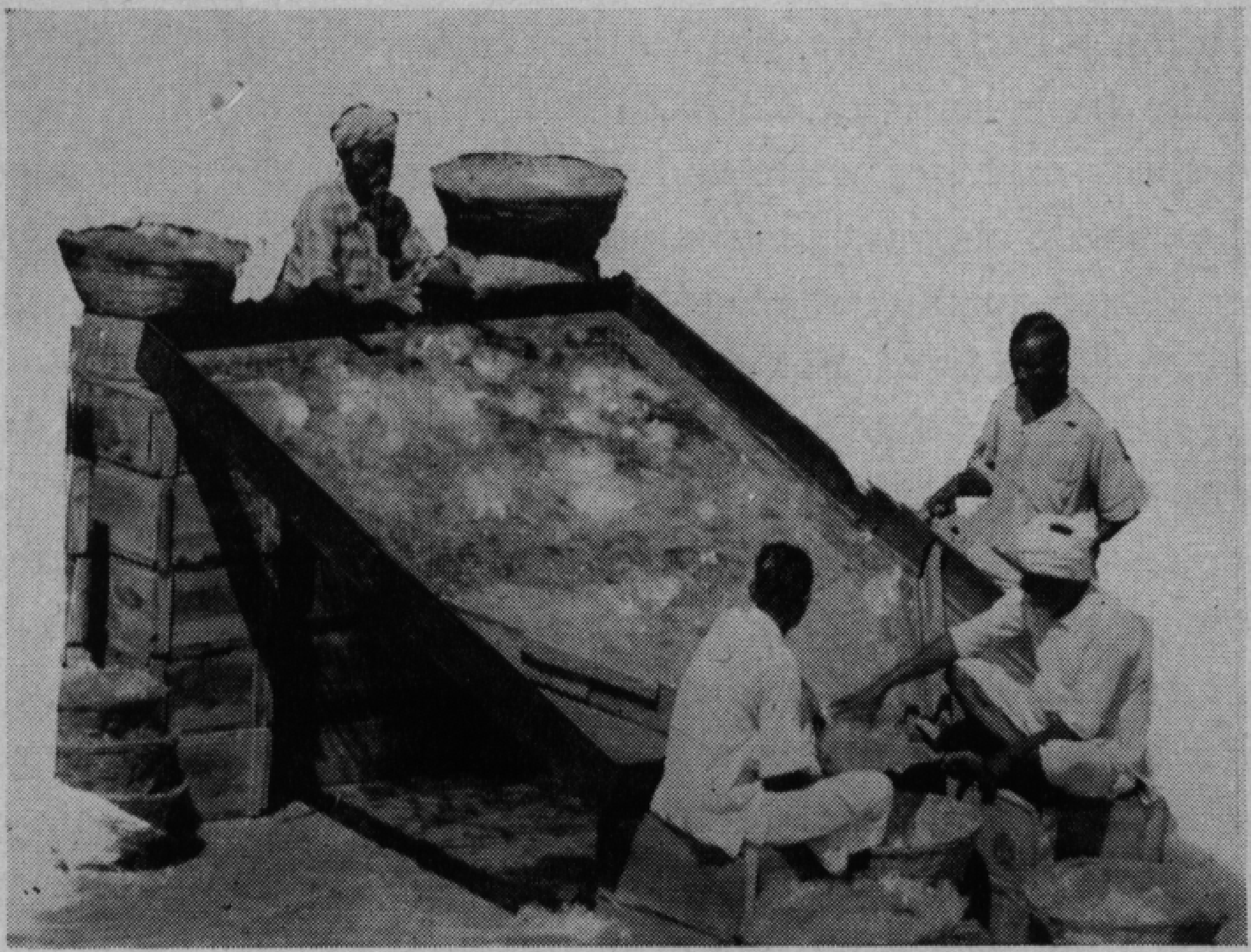


FIG. 49. Type of hand shaker screen employed for screening the bulk of all grades of No. 6 loose splittings.

No. 5½ loose splittings	1¼- or 1½-in. mesh
No. 6 first-quality loose splittings	¾- or 1-in. mesh
No. 6 second-quality loose splittings	½- or ¾-in. mesh
No. 6 third-quality loose splittings	⅜- or ½-in. mesh

Careful handling of splittings by persons who sprinkle them over the screen at the head end and by those who collect the screened product at the tail end is necessary to prevent undesirable damage.

Mostly, the larger grade loose splittings, such as grades 4, 5, and 5½, as well as considerable quantities of No. 6, are generally required by the consumers in powdered form. The powdering of these splittings is done more or less in the same manner as in the case of book-form splittings.

There is, however, one very important point to be borne in mind with regard to the screening of splittings, and that is that the uniformity of the quality of the bulk of screened splittings depends largely on the uniformity of the gradients or slopes of the sieves used for screening a particular bulk.

Moreover, suitable gradients or slopes must be fixed according to the average size of splittings required, as otherwise, with too steep a gradient, the bulk slides down too quickly, without the proper elimination of undesirable small pieces. On the contrary, if it is too flat, it may result in an excessive rejection of usable splittings.

A considerable elimination of objectionable spotty or stained splittings is achieved in the screening department, while the plus product from the sieve is collected by labourers from the tail end of the screen and whatever is left by mistake is further eliminated by packers, while the bulk is packed in cases. Splittings are packed in cases of 100 lb. or 125 lb. net.

The screens used for sieving loose splittings are made of hexagonal wire nettings of specified sizes fixed to wooden or steel frames, as shown in Fig. 49. The most suitable size of frame is 8 by 6 ft. The screens are vibrated by striking the wire netting at the bottom of the center of the sieve with the help of a flat wooden piece attached to the end of a stick.

The larger grade loose splittings are packed in packets or directly into cases, as may be required by the buyer. The clipping of torn and ragged edges and the elimination of spotted and undersize films from these splittings are done at the time of packing, as far as economically practical.

BOOK-FORM SPLITTINGS

The type of mica generally used for the preparation of book-form splittings has been described on pages 148 to 149. The special feature of the manufacture of these splittings is that, as the films are taken off a particular piece, they are powdered, usually with mica powder, and placed together, so that the original shape of the block is maintained and all the films of a particular book may be spread out like a pack of cards, as shown in Fig. 50. The powdering of splittings is done with the object of preventing the films from sticking to one another. The entire process is quite a simple one but needs long practice and some dexterity. Adolescents and female workers are found to be especially suitable for this particular job, and the swiftness the splitters have acquired by constant practice is remarkable. Figure 51 shows a girl manufacturing these splittings.

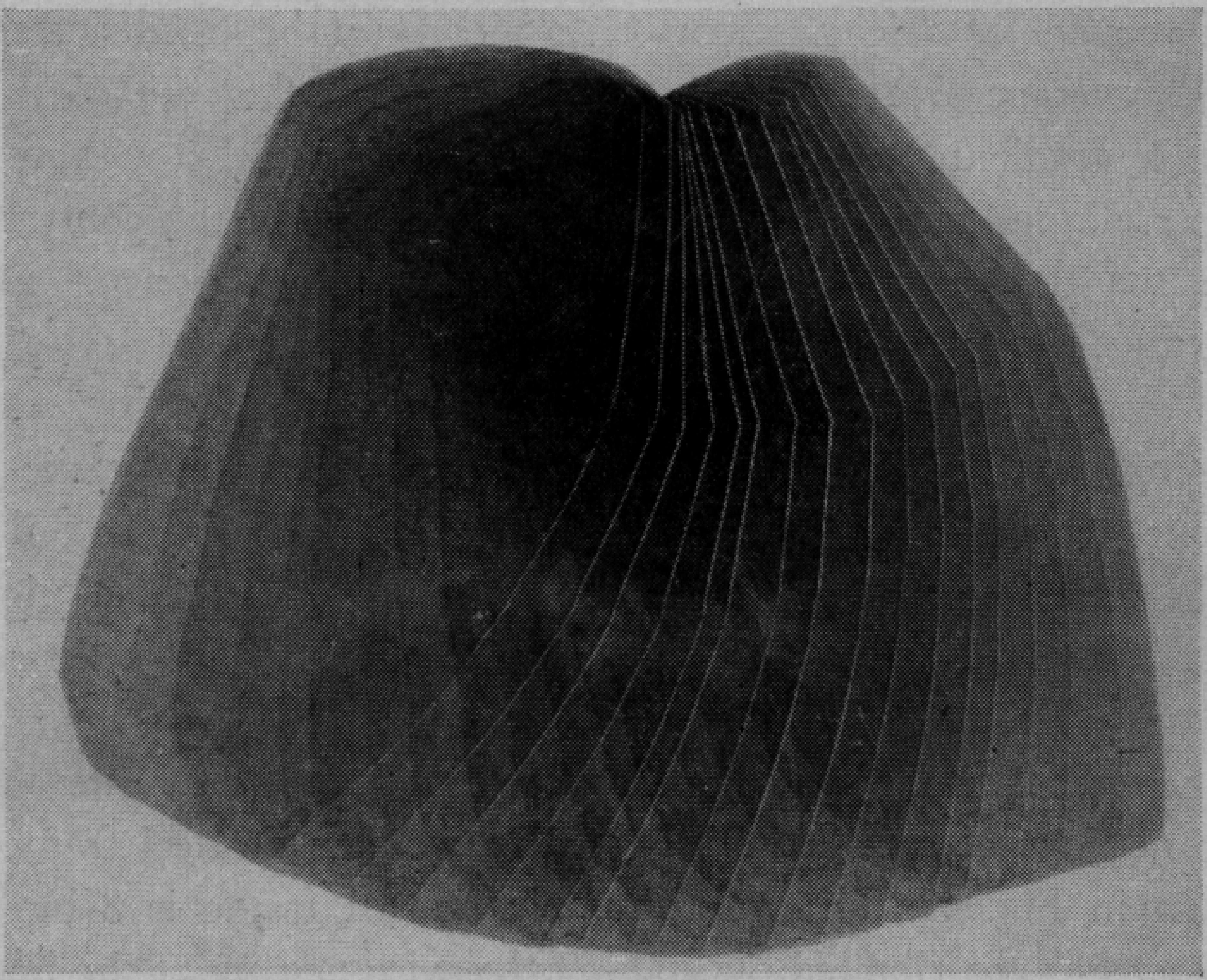


FIG. 50. An example of book-form mica splittings.

The most difficult part of the entire operation is efficiency of management, such as will ensure the maximum recovery of finished product from the bulk of random-thickness block mica. Since the entire operation is dependent on hand labour, the slightest carelessness on the part of the splitters results in an excessive production of torn films, which have to be eliminated at the time of packing.

At the very outset, the splitter takes a thick film of, say, 2 mils or so off a piece of block and then tears it at one corner to produce a beveled edge for enabling him further to split the thick film to the required fineness. If such tears are not carefully located at projecting corners outside the forma, a considerable bulk is rendered undersize, resulting in an undesirable reduction in the value of the bulk. This is explained graphically in Fig. 52.

The illustration represents a piece of No. 5 mica, which can just accommodate a rectangle of 3 sq. in., *i.e.*, the rectangle of the minimum area that is required for the inclusion of the piece in No. 5 grade. Now if a careless splitter tears this piece at point *a*, which is very close to a side of the rectangle, the tear thus produced may intrude into the rectangle and the piece will be unavoidably rendered undersize at the time of packing, when the packer cuts the V, shown by the area covered by the hatched line, to eliminate the crack. This can very easily be avoided, if, instead of tearing at *a*, the splitter tears the piece at point *b*, which is the farthest from the side of the rectangle. Again, if the tear is longer than necessary, it results in an excessive production of cutting at the time of packing.

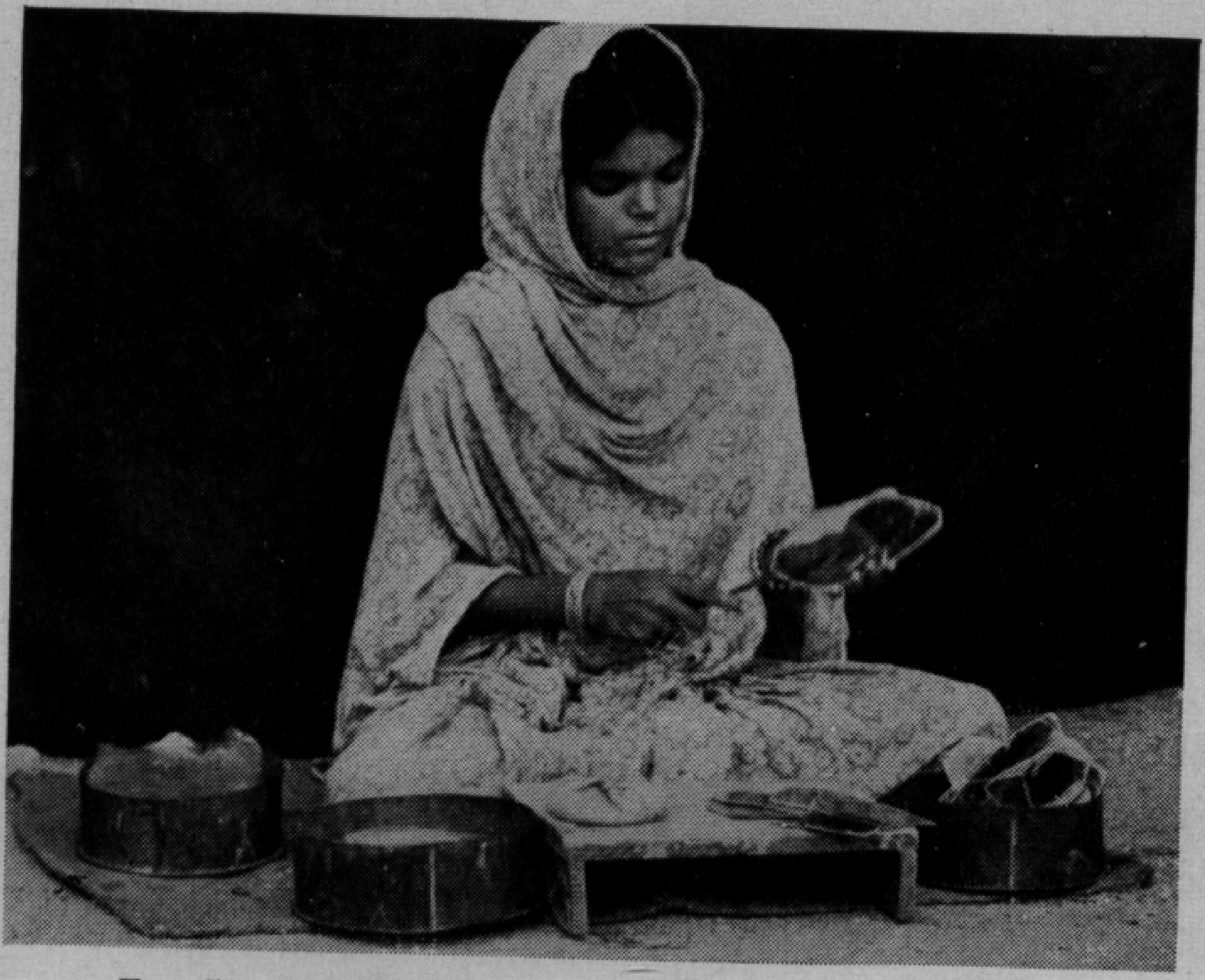


FIG. 51. A young girl manufacturing mica splittings.

It is essential that all the films belonging to a particular piece should have the tear in the same place, for if a careless splitter tears different films at different places, the fate of the split book can easily be imagined. The tearing of thick films is locally known as taking *chutḳi,* meaning an allowance for tearing only a minute portion of the book that can hardly be accommodated between the ends of thumb and finger. It sounds negligibly small, but its effect is great.

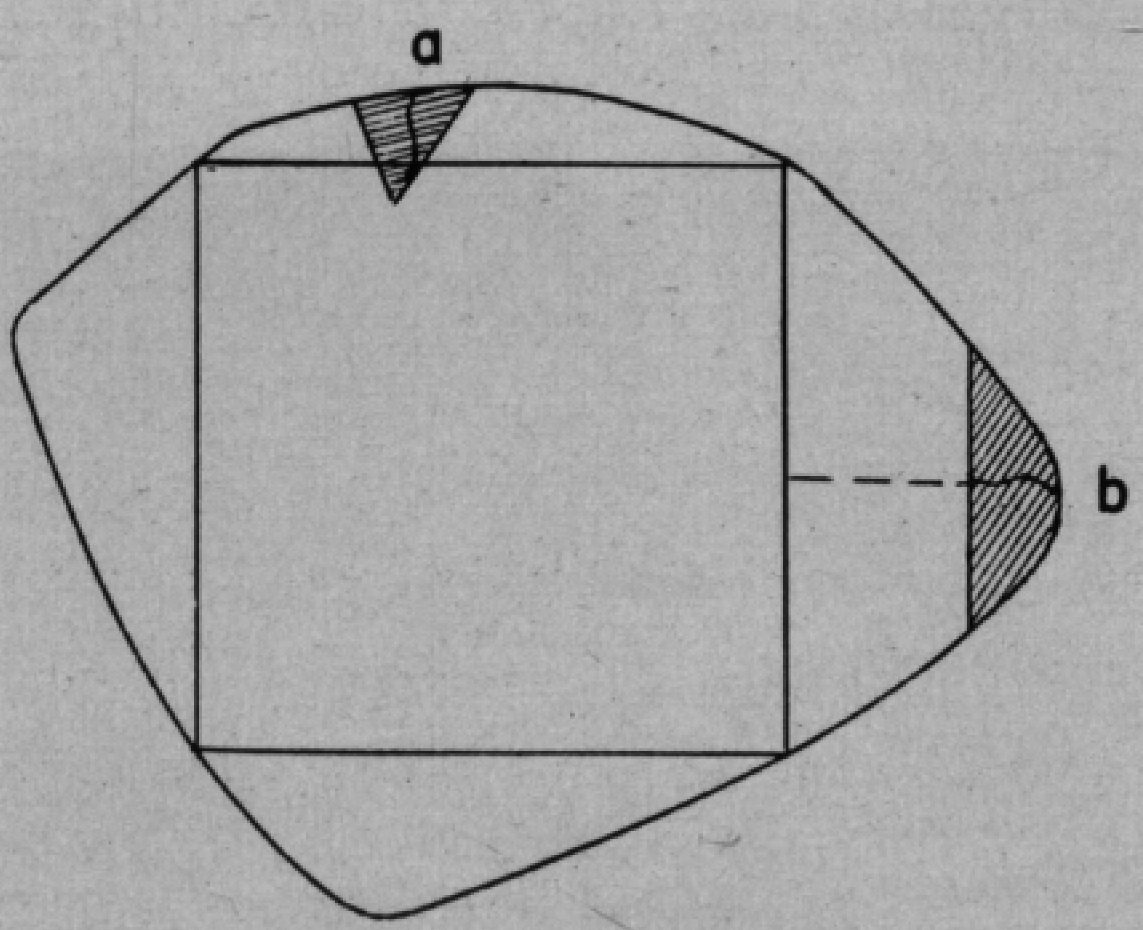
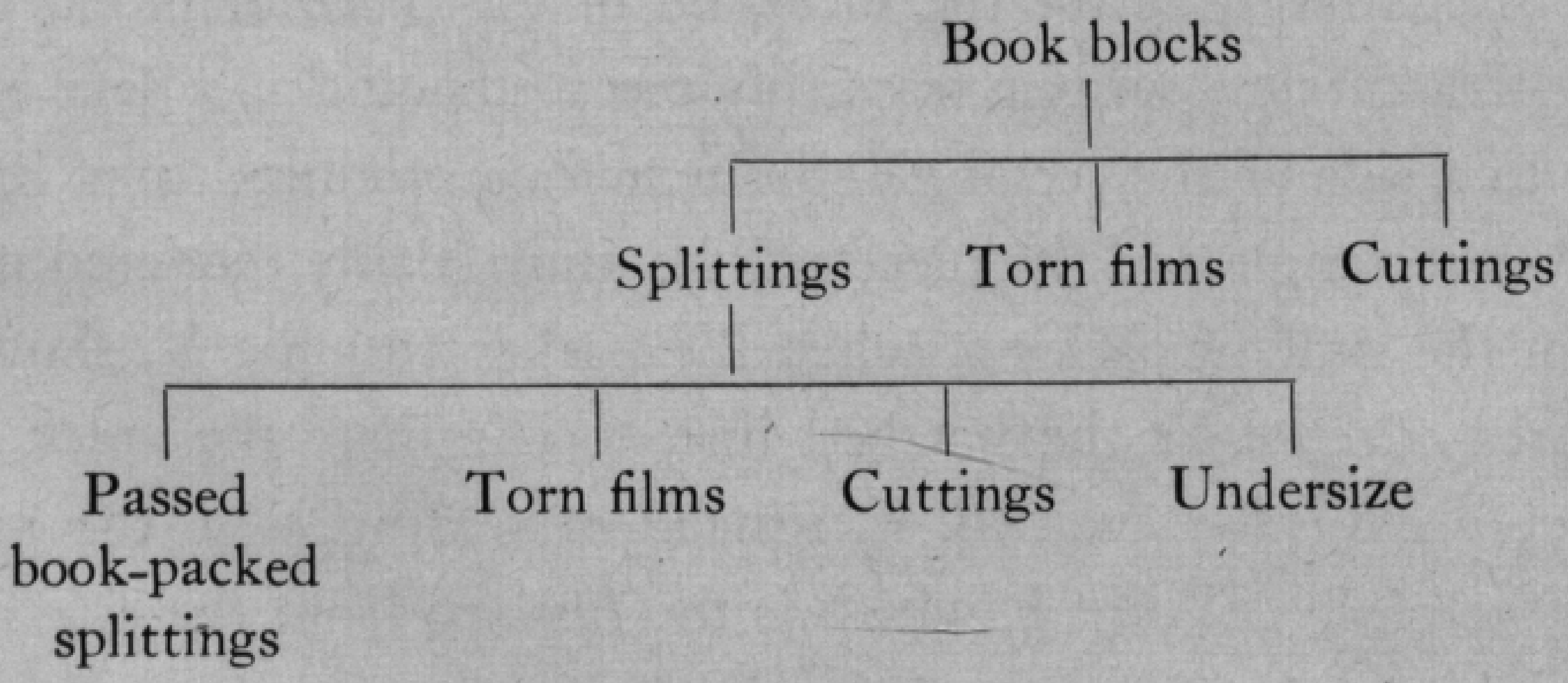


Fig. 52. Sketch illustrating how the carelessness of a splitter can reduce the value of a book of mica by rendering it undersize.

These splittings are generally split to a thickness of about less than a mil, unless otherwise specified by the buyer. There is often a demand for these splittings split to a thickness of ½ to ¾ mil (0.0005 to 0.00075 in.) in the European countries.

FLOW SHEET 7



Flow sheet 7 gives a complete picture of all the waste factors, which, to be precise, are always inversely proportional to the quality of supervision, and it will be no exaggeration to say that, in exceptional cases, the yield drops down from 80 to 60 per cent.

In view of these serious consequences, careful management of this particular department is imperative. The best way of ensuring a thorough check is to have a chart showing the waste factor involved in the product of each splitter in both the splitting and the packing department. This has been given a thorough trial in one factory for several years, with most satisfactory results.

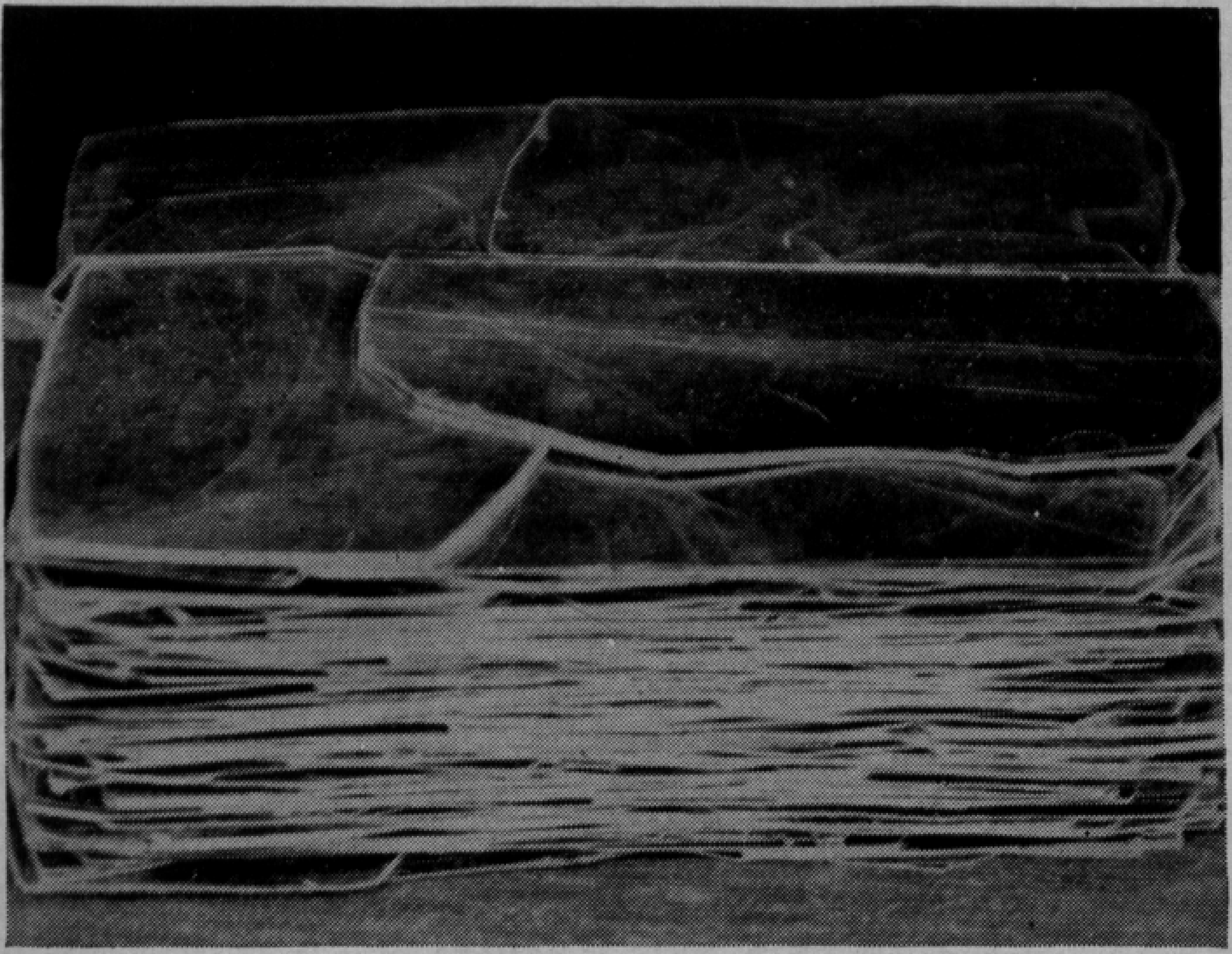


FIG. 53. A packed packet of book-form mica splittings.

As shown in flow sheet 7, after a bulk has been split, the entire bulk of resultant splittings is transferred to the packing department, where each book is carefully examined. Ragged sides are trimmed, *chutkies* are clipped, and torn films, as well as films with objectionable spots and stains, are eliminated. After the book has been rendered reasonably sound, the size is measured; and then it is finally put in a packing frame, which usually is a bottomless square-shaped box placed on a piece of packing paper to enable the arrangement of passed pieces in a regular way, with a view to having a square packet, as shown in Fig. 53. The entire operation of checking and correcting the split bulk prior to packing is locally known as "passing." Usually these splittings are done up in packets of 2 or 5 lb. each, which are then packed in cases of 100 lb. net weight.

PAN-PACKED SPLITTINGS

In manufacturing these splittings, advantage is taken of that peculiar property of mica which allows two freshly split films to stick to each other when pressed by hand. All the split films are uniformly arranged in a circular (Fig. 54) or square pan, as the case may be, according to the specification of the buyer, and after a certain thickness, of, say, ⅛ in. or a little over, has been achieved, a circular or a rectangular piece of cardboard is placed over the splittings in the pan and the entire bulk of splittings under it is subjected to hand pressure. After this, the cardboard disk is replaced by a thin paper disk, over which the second installment of splitting is arranged; and when the level of splittings again rises by ⅛ in. or so, the thick cardboard disk is inserted again for the application of the requisite pressure. This process continues till the pan is nearly full, and then the entire bulk is pushed out of the pan with the finger through the circular hole of about ½ in. diameter located in the center of the bottom of the pans. The entire manufactured bulk comes out of the pan in the shape of a number of circular thick pieces of mica, as shown in Fig. 54.

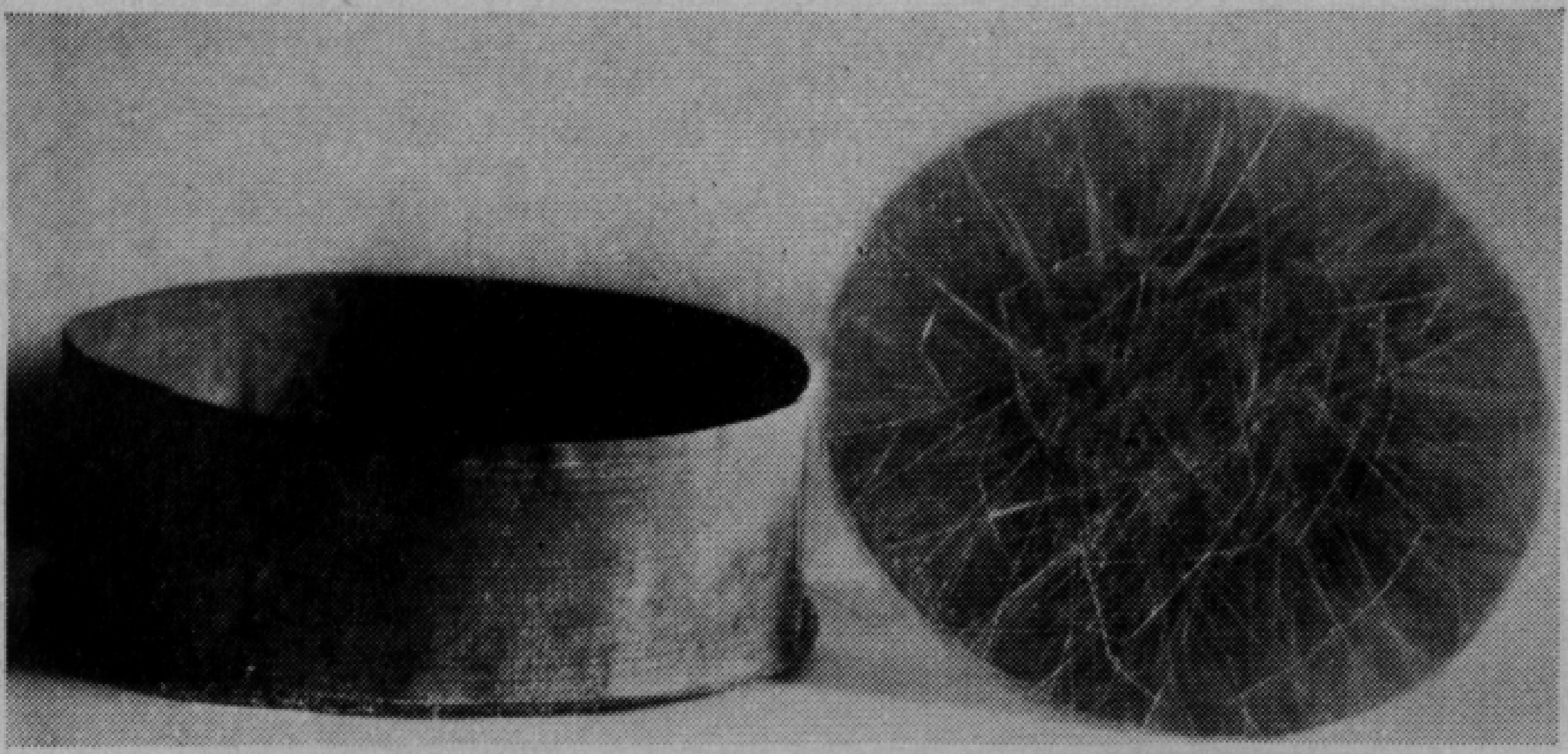


FIG. 54. A photograph of pan-packed splittings and the pan used for its manufacture.

Such pan-packed splittings of practically all grades (generally from No. 6 to No. 4) are manufactured by the home splitters.

Wrapper Splittings

The manufacture of wrappers is practically the same as that of book-form splittings, except that in the case of wrappers no mica powder is used. Each film, as it is taken off a piece, is wiped on both sides with a piece of cloth, in order to prevent two films from sticking to each other. Another difference between book-form splittings and wrappers is that in the case of wrappers the thickness of the films is specified and is generally ¾ in. to 1¼ mils.

The passing and packing of wrapper splittings is done in the same manner as in the case of book-packed splittings. In addition to the normal inspection given to a book for rendering it reasonably sound, films that are thicker or thinner than the specified thickness are eliminated from the bulk at the time of passing, before packing.

Condenser Films

The manufacture of condenser films requires the most skilled and experienced labour, for in this case mica has to be split to a number of specified thicknesses, such as

¾ to 1¼ mils
1 to 1½ mils
1¼ to 2 mils
1½ to 3 mils
2 to 3 mils
3 to 4 mils

Generally, the demand for condenser films is in grades 3 to 6. Good stained blocks and chillas are used for manufacturing second-quality condenser films and fair stained blocks and chillas for first quality. In both cases, some amount of production of the next higher or lower quality of films is inevitable.

There is one interesting point to be noted in this connection, that, with comparatively little practice, the Hazaribagh labourers acquire an extraordinary skill in splitting a bulk to specified thickness, correct to 75 to 80 per cent, without much help from a micrometer (Fig. 55). This is, however, practicable only when the splitters are confined to one particular thickness for some time. If there are frequent changes of thickness, micrometers have to be used more often by the splitters, and the production declines appreciably.

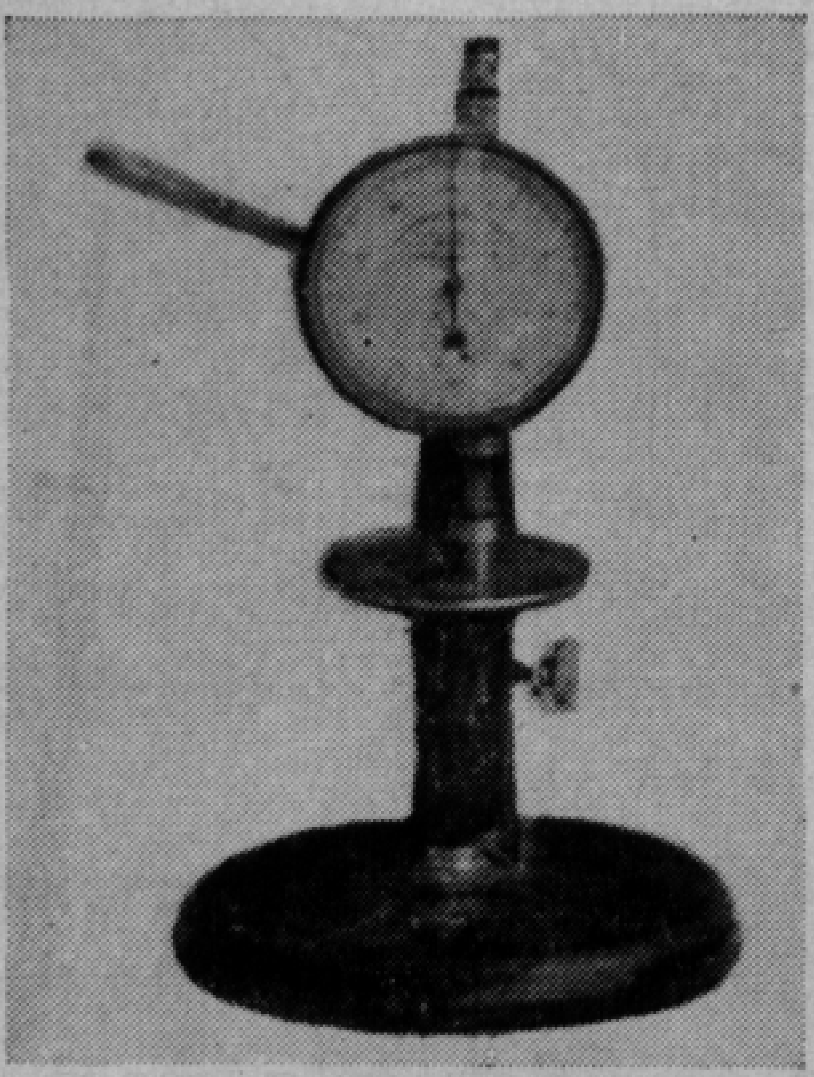


FIG. 55. Micrometer used to measure the thickness of condenser films. It measures up to 1/4,000 in.

The passing of split condenser films before packing presents considerable difficulties, for each film thus split must be examined by the packer in order to check the quality and thickness and to eliminate defects like cracks, undersize, etc. Thus the cost of manufacturing and packing condenser films is the highest of all the items incurred in the various departments of a mica factory. Condenser films are manufactured both in book and loose forms, according to buyers' requirements, and are put up in packets as in the case of book-packed splittings.

Capstan micrometers, capable of measuring up to 1/10,000, are also used these days, when extra precision is called for or when it is necessary to furnish films or plates gauged to a difference of 0.00025 in., *i.e.,* 0.00125–0.0015, 0.0015–0.00175, 0.00175–0.002, etc.

CHAPTER 8

Labour and the Occupational Diseases

The unorganized condition of labour in the Bihar mica fields presents a problem that is as old as the mica industry itself. At every stage of production, the efficiency of the industry is largely dependent on the labour factor, and one can therefore value the importance of a stable and well-trained labour force. Labour in the mica industry can be divided into the following four groups:

1. Mining labour.
2. Upperchella labour.
3. Home splitters.
4. Factory labour.

Mine labour mostly receives a daily wage. The labour force in the mining areas is mostly drawn from the local population, which is predominantly agricultural and is concerned only to cover the deficit in their domestic budget by their earnings from the mica fields.

Consequently they do not work, on the average, more than 3 to 4 days in a week. Besides, they do not stick to one particular concern, but keep on changing masters practically every week.

Unfortunately the mines are located in the deep forest, like the Government Reserve Forest. Absenteeism is more marked because these mines depend exclusively on labour recruited from within a radius of 40 to 50 miles. Taking into account all the circumstances, such as cultivation during the rainy season and numerous festivities, both social and religious, accounting for absenteeism, mine labour in general works at best for about 6 months in the year. This irregularity of attendance accounts mostly for the ridiculously low efficiency of labour in the mines, especially in those in which compressed-air drilling is done.

The engineer prescribes the simplest possible method of placing and pointing drill holes, but the workers, on account of irregular attendance and their migratory habits, can neither be taught any particular method or system of drilling holes correctly nor be made to acquire enough practice to work on compressed-air drills efficiently. As a consequence, at least 25 per cent of the holes they drill are either misplaced or wrongly pointed, resulting mostly in "blown-out" shots. Hence, practically 25 per cent of the money spent in drilling and blasting is completely wasted. In the absence of constant practice, the drillers drill at the best 40 ft. of holes in one full shift, even with a steady supply of air pressure at 80 lb. Though compressed-air mining has been practiced in the Bihar mica fields for the last quarter of a century, even today the working efficiency is not more than 40 per cent of what it should be. The trouble is further augmented by the uncertainty of labour supply on each day. Only on a very few days is a mine lucky enough to get the requisite number of both drillers and muckers (labourers employed for clearing debris from the mines). When the drillers turn up in strength, the number of muckers is inadequate, or vice versa. Under these circumstances, even if the desired quantity of rock is broken, for want of muckers the faces cannot be cleared for the next round, or even if there is sufficient labour to clear the debris from the mines, the number of drillers required to provide enough work for them is not available. Mines are, therefore, mostly worked with an unbalanced labour force, and one can well imagine its consequences on the ultimate cost of production.

This lack of sufficient workers, together with unhealthy labour conditions in the mining areas of Bihar, has been attracting the attention of the government as well as the industry for a long time. It is believed in some quarters that if reasonably comfortable living conditions and certain other amenities are provided for the mine workers, it may be possible to have a stable and reasonably efficient labour force. With a view to improve labour conditions the government of India has levied a tax, called "labour welfare cess," of 2½ per cent on all exports of mica from India. Tentative proposals that have been put forward so far, with regard to how the money should be spent, include a housing program, improvement of mine roads, and hospitals in the mica areas with up-to-date equipment, etc. So far as making good roads and building hospitals are concerned, there is little to say. But as regards the proposed housing scheme, considering the unpredictable behaviour of mica pegmatites, the shortness of their life, and the consequent need to shift camps at intervals, I must argue against optimism as to the success of this scheme.

It is suggested in some quarters that these difficulties could be overcome if houses were built in some central place and the labourers conveyed from there to the mines by busses. But even assuming that good roads will be made available to the industry for the transport of labour to the mines, in view of there being numerous concerns carrying on mining operations, the above suggestion seems to involve considerable practical difficulties, especially with regard to proper allocation of space in such centers to different concerns and its proper utilization. Moreover, so long as the labour force must be drawn from local farming areas, arrangements for housing cannot by themselves be expected to improve the attendance. Some principal producers of mica who have to depend on labour recruited from distant villages (located within a radius of 50 to 60 miles) have already made their own arrangements for accommodating such recruited labour. But the results so far obtained have not been at all satisfactory.

In 1948 disputes relating to wages, bonuses, and other amenities demanded by the local trade unions with respect to both mine and factory labourers were referred to the Government of India's Industrial Tribunal. The Tribunal's award gave an increase of about 60 per cent in labour wages. Besides, attendance bonuses amounting to 15 to 20 per cent of a month's consolidated earnings, quarterly bonuses equivalent to half a month's basic wages, and a number of other amenities were also granted to the workers. As a net result of this award, labour charges increased by more than 100 per cent on the average.

The labour representatives, while arguing the case to support their demands, quite emphatically assured the Tribunal that, if their demands were met, both the attendance and efficiency of labour would be improved considerably. But it has to be regretfully recorded that, in spite of the labour demands' receiving most favourable consideration in the hands of the Tribunal, the promised improvement in general efficiency or in attendance has not yet been effected. On the contrary, a marked deterioration in the efficiency of labour has been observed.

In the light of the foregoing facts, one cannot help but conclude that, so long as the Bihar mica industry has to depend on local labour, which has one foot in the paddy fields and the other in the mica mines or factories, these chronic, unhealthy conditions will continue to persist. The real basic improvement will depend on the creation of a labour force that will not look to other occupations to eke out its livelihood.

In large mining enterprises like Mosabani copper mines in Singhbhum, the Bawdwin mines in the Northern Shan States (Upper Burma), or the Kolar gold fields in Mysore (South India), etc., very little local labour is employed, as practically the entire labour force has been drawn from different parts of India. These mines are operated by more up-to-date methods and the availability of a stable labour force accounts for their highly efficient operation.

Enough has been said about the part played by the upperchella workers and home splitters in the chapters on Prospecting and Processing. These labourers work on either a contract or a piecework basis, and, so long as the prospecting of mica is dependent on the natural instinct of these upperchella workers and the manufacturing of the smaller grade loose splittings must be done at a low cost, no appreciable improvement in the existing conditions can possibly be effected.

The importance of factory workers has been described in the chapter on Processing. Though these labourers are much more regular in attendance than mine labour, they lack the care and sense of responsibility necessary to avoid undue waste in processing. The problem of improving the factory labour also, therefore, calls for serious consideration, in spite of its better record in the matter of attendance.

This defect has increased considerably within the last few years; as a consequence, not only do the labourers produce less than half the work they used to, but the waste factor has increased seriously.

Occupational Diseases

Malaria. The unfortunate location of the mica mines in deep forest areas inevitably exposes the workers to the dangers of malarial infection. The virulence of the infection varies with the season, and during and after the rains, at times, malaria is liable to break out in epidemic form. Malaria in the mica fields of Bihar is chiefly of the benign tertian type, but the occurrence of malignant infections is by no means uncommon. In some areas, especially in the Government Reserve Forest, malignant infection is particularly virulent and the loss in lives and in health is heavy. As a consequence mining operations in those areas come practically to a standstill during the rains.

The war gave rise to an acute shortage of quinine in all forms. In fact, the quinine bi-hydrochloride, which was most popular as a remedy for treating all forms of malaria, especially the malignant tertian, was almost extinct. Consequently it became extremely difficult to deal with malarial cases for a considerable period of time, until mepacrine was made available in abundance. But unfortunately this particular drug, though it was found generally useful for cases of benign tertian, had not the same effect on malignant infections. In the mica-mining centers, mepacrine could not gain popularity, especially amongst labourers, which may be attributed to lack of confidence in a new drug. Moreover, unfortunately for this drug, it produced undesirable toxic effects in a few cases. However, some quantities of quinine sulphate were also made available to the mica industry, and the situation was met somehow or other by both these drugs.

In pre-war days, administration of quinine hypodermically produced marvelous results in acute cases of malignant infection. For those susceptible to abscesses, especially among the superior staff, quinoform injections with oral administration of atebrin were found most effective.

The general devitalization of labour on account of scarcity of food under war conditions, coupled with a shortage of proper drugs, made the prognosis of the malarial cases more complicated.

Mica-mining labour generally does not escape from intestinal fluxes (*e.g.*, dysenteries of various origin, ulcerative colitis, cholera, and para sprue). This is mainly attributed to indiscriminate drinking of unwholesome water from sources like small potholes dug in the bed of rivulets or unhygienic wells. But the comparatively higher standard of vitality and immunity that these children of nature develop protects them from the deleterious effects of these fluxes. Cholera, however, is an exception; and it visits the mica field with periodical explosive virulence in the late summer, when there is high humidity with extreme heat and a plenitude of indigestible foods like jack fruit and maize, which the labourers eat greedily.

It is a pity that in spite of the repeated havoc created by the annual visitation of cholera, no effort has yet been made for preventive mass inoculation, which has successfully effected a total eradication of this disease in some advanced countries.

Ancylostomiasis. Marshy lands hidden from the direct rays of the sun provide the most fertile soil for the growth of the Ancylostoma ova and larvae. Any man who walks over such marshy lands or drinks the unwholesome water of such a place is generally susceptible to this infection. Ancylostoma ova, which enter the human system through drinking water, pass through the stomach and become lodged in the intestines, while the larvae penetrate through the skin of the feet and get into the blood vessels and finally settle down in the intestines, where they live on the hosts' blood, causing anemia. Since this disease is common in most parts of this country, in the absence of separate statistics collected on a clinical basis, it is impossible to state definitely whether its existence in the mica fields is accountable by special causes. Moreover, the natural immunity that these villagers develop against this disease prevents manifestation of the symptoms, unless a devitalized body falls an easy victim. However, acute cases of Ancylostomiasis are detected and treated by oil of chenapodium and carbon tetrachloride. Generally, a dose consisting of 25 minims of each of these drugs followed by a strong salt purgative has been found to produce satisfactory results amongst the mica labourers.

Venereal Diseases. The greatest curse of civilization is the incidence of venereal diseases, and mica labourers are affected as well as any other class of people.

In view of the advanced mass treatment that has been evolved in recent years, it has now become extremely essential for the sake of the general health of these labourers that the government should take this matter up seriously and try to organize venereal clinics in the mica areas.

Silicosis. Apart from these diseases, which can aptly be called environmental, silicosis has become an occupational disease with the introduction of compressed-air drilling in the mica mines. Even today in most of the mines drilling is performed dry. This releases large quantities of fine silica dust (SiO_2), saturating the atmosphere of the underground working places. The labourers and the supervising staff working in these faces inhale considerable quantities of silica dust, which ultimately gets deposited in the alveoli of the lungs. It is very difficult to estimate the number of lives lost because of this menace, but it can be said without exaggeration that the incidence of silicosis on the mining labour as well as the supervising staff creates a serious problem. In the early stages of this disease, a patient may have occasional bouts of temperature with pain in the chest and invariably difficulty in breathing and at a slightly advanced stage, he starts spitting blood, has a low rising evening temperature and remission of the same very early in the morning, with profuse perspiration—a picture closely simulating tuberculosis.

Since this disease is not commonly met outside mining areas where dry drilling is in force, it is sometimes misdiagnosed by the medical practitioners as tuberculosis. An X-ray photograph of the lungs of a silicotic patient shows characteristic arborization, usually confirming the diagnosis. Since the symptoms are somewhat similar to those of tuberculosis, it is sometimes very difficult for a medical man to diagnose it correctly unless he is provided with a clear and authentic history and findings of each case.

The presence of considerable silica dust is observed in some cases in the sputum of silicosis patients. In one particular case, where silica dust was not visible to careful microscopical examination, I prepared a slide and examined it under a petrological microscope. Interesting results were obtained by the study of the same under the polarizor or the Nicol prism of the microscope. The slide showed the presence of fine quartz crystals in large quantities.

If silicosis is detected in its early stages, further damage may be prevented by withdrawing the sufferer completely from underground work.

The sequel of this disease, which is, strictly speaking, a physical injury, is the pretubercular state. The silicosis hazard could be prevented to a great extent if a government regulation prohibited dry drilling. Mines employing wet-drilling methods tend to reduce the silicosis hazard. Labourers working in mines employing hand drilling rarely show any sign of silicosis in the mica fields.

It is erroneously thought by some casual health visitors that the mica dust in the mica factories gives rise to silicosis. Except, perhaps, in the screening operations of mica splittings in the factory one will not experience a dusty atmosphere. In fact it can safely be said that a healthy and clean environment can be provided for labour to a remarkable extent in a mica factory. But even those working in the screening plants for a decade or two have not shown any sign of silicosis.

A worker in this department was X-rayed and the photograph of his lungs was described by the radiologist as being no different from the lungs of a professional motor driver, who is exposed to dust more than a normal man. This may be attributed to the fact that silica dust particles of less than 10 microns do not get deposited in the lung parenchyma.

In some areas, of course, scarcity of water may present considerable difficulty in introducting wet drilling, but such difficulty should be regarded as seasonal and is limited only to the height of the summer season. Moreover, considering the disastrous effect of dry drilling on the workers, even if one has to sacrifice some amount of working efficiency for 3 or 4 months in the year, one will be actually repaid in the long run. No exception should be made, therefore, because of seasonal water scarcity.

Some people believe that wet drilling is expensive. As a matter of fact, in comparison with the gain in working efficiency obtained by wet drilling, the cost involved is practically negligible, whereas the protection of the health of the workers is invaluable.

Tuberculosis. The existence of extensive tuberculosis infection amongst the miners and the factory labourers, though suspected by many people, is dubious. In the absence of a scientific public-health survey of tuberculosis and silicosis amongst the miners and the factory workers, it is extremely difficult to offer a categorical statement. It may be present only to the extent that it is common among the population of this country. However, to get a true picture of this vitally important problem the government should conduct a thorough survey of the mica belt with the aid of mass-production X-ray photographic equipment. This method has become more popular in the industrial areas as well as in American mining districts. Moreover, such mass miniature radiography is not too expensive and should be within the means of even our provincial governments.

CHAPTER 9

Standardization of Mica Qualities

In the mica world, the question of quality standardization of mica has become a highly controversial subject. According to some, standardization of qualities is both practicable and necessary, while others reject it as impossible or absurd. Much may be said for both sides, but at the same time it cannot be denied that standardization is desirable and that no regular marketing organization is conceivable in the absence of fixed quality standards.

Let us, to start with, examine the arguments put forward by those in favor of standardization. The principal producers and exporters of mica consign their stocks either to their own agents abroad or against firm orders, mostly from middlemen or brokers and rarely from consumers direct. Such consignments or shipments are sold to or are accepted by the ultimate buyers after inspection. In most cases it has been found that, on the average at least, invoice prices are easily obtained. Substantial business is also done against 100 per cent letters of credit, negotiated against shipping documents; and even in such cases, the supplies generally meet with the approval of the buyer. Except in rare cases, no dispute of consequence ever arises with regard to the quality of the supplies furnished by reputed concerns against full credits. All such consignments or shipments against letters of credit are made on the basis of different standards, for each shipper has a standard of his own. Now, all the mica shipped by an individual shipper does not come from a single mine but consists of a heterogeneous mixture of mica from different mines. Hence, in spite of all this, it is argued that, when one can sort a mixed bulk to particular standards and successfully transact business without any appreciable dispute, one has naturally to infer that standardization of quality is possible. If a mixture of the product of several mines can be sorted to the particular standard of a particular buyer, there should be no difficulty in sorting the same bulk to a general fixed standard.

Now let us examine the other side of the story. The opponents of fixed and controlled standards say that the world for years had no precedence for fixed quality standards of any sort, and the Indian mica industry had been transacting business on the aforesaid lines since its very inception, until, for the first time in the history of mica, a departure from this rule unfortunately occurred during World War II. In 1941, soon after the war's outbreak, purchases of mica were made against fixed standard by the Geological Survey of India for the United States and were based on three successive standards, *viz.:*

1. Government of India standards.
2. Revised or stock-pile standards.
3. Metal Reserve Company standards.

The Government of India standards were fixed by Mr. John Podger, the then Government Mica Inspector. Tenders were invited from the industry on the basis of samples to these standards; but unfortunately no appreciable business materialized, for the buyer did not agree to the prices quoted by the Indian mica trade. This led the government of India to invite representative samples of their requirements from the United States government, on the presumption that the qualities offered against Government of India standards were probably higher than those required by the United States.

When the United States government's standard representative samples, known as "Stock-pile Samples," were received from the United States, they were examined jointly by Mr. John Podger and Mr. Elbridge Watson and were found to be very much inferior to the Government of India or any other Indian standard. Consequently these samples were not released to the trade, and the director of the Geological Survey of India continued to invite tenders on the basis of Government of India standards. But when the recommendations of the director of Geological Survey of India, based on the Indian government standards, were turned down repeatedly because of "price out of line," the United States Stock-pile

Samples were reluctantly used as a basis for a modified series of samples, and a substantial business was then done on this lower or American standard. As might have been expected, when shipments of this revised standard reached the United States it was discovered that the mica was of a much lower quality than was evidently required. This naturally gave rise to considerable controversy, since the American inspectors claimed their standard samples were of superior quality to the material purchased for them. However, there is no doubt that the Government Mica Inspector of India had accepted deliveries from the trade only after assuring himself that they compared favorably with the revised or American standard. After some confusion, it was finally discovered that the mistake lay with the American authorities who had been responsible for the preparation of the substandard American Stock-pile Samples.

In the meantime, however, Mr. G. H. Tipper, from the British Embassy in Washington, had come to India to assist the United States government to solve the riddle, and it was he who, with Mr. John Podger, prepared new samples for the Metal Reserve Company and took back to the United States with him samples for approval by the United States government. It also was he who eventually discovered the mistake made in regard to the stock-pile samples sent to India. The samples made by Messrs. Tipper and Podger were accepted as the M.R.C. samples. Substantial business was done on the basis of these M.R.C. samples also, although a considerable part of the supplies made against them were also turned down by the M.R.C. on the ground that they were not up to standard.

Ultimately, His Majesty's Government was invited to send out a Joint Mica Mission to purchase mica for His Majesty's Government and the United States and for allied requirements generally. Members of the Joint Mica Mission included both British and American mica importers and brokers with experience in Indian mica. Quality standards were fixed by the Joint Mica Mission for mica of all descriptions, and all mica purchased by the mission was inspected by their own inspectors, under the supervision of one of its resident technical members. Unfortunately, again, this system did not give full satisfaction, as was evident from the numerous complaints that were received by the Joint Mica Mission both from the United Kingdom and from the United States with regard to the quality of their shipments.

This is borne out by the following observations made by the Mica Enquiry Committee in their report.

> We were shown the Mission's file of valuation reports on stock received in the United Kingdom, and found several comments to the effect that supply was as much as 50 per cent below standard. Among the firms affected by these comments were some of unexceptionable reputation, the honesty of whose sorting cannot be questioned.

But the inference the committee has drawn from the above-stated observations does not appear to be at all logical when they say:

> In these circumstances the comments suggest that they were based upon somewhat higher standards than those accepted in India by the Inspector of the Joint Mica Mission; in other words, that there was really not a common standard. Complaints and misunderstandings of this sort would, we feel, be avoided if there was a proper standard enforced by a competent authority.

Moreover, the contention that there was really not a common standard is too obvious to be discarded prima facie, for one cannot possibly afford accommodation to such thoughts as that true copies of standard samples were not sent to the United Kingdom and the United States by the Joint Mica Mission for the comparison and appraisal of their purchases, by the distributing authorities at the consumers' end. In any case, this system of purchase by a body like the Joint Mica Mission, against quality standards fixed by fully competent representatives of the consumers' countries, and without any interference whatsoever from the Indian mica trade, is the best that could be devised, especially in the interest of the consumers; and there certainly could be no better competent authority than the technical members of the Joint Mica Mission to set and enforce proper standards. Moreover, all the deliveries made by the trade to the Joint Mica Mission were accepted only after a very strict inspection, which is obvious from the rate of rejection of deliveries by the Joint Mica Mission Inspectorate, which at times was exceptionally heavy. If, therefore, in spite of the best system that could possibly be devised for safeguarding the interest of the consumers against any possibility of the supply of substandard materials, some of these materials supplied especially by a concern of unquestionable integrity were nevertheless declared to be 50 per cent inferior, the situation thus created can have no plausible explanation, except that such comments have originated through a wrongful comparison of the bulk with superior standards, as has been apprehended by the Mica Enquiry Committee, in which event it was clearly a case of misunderstanding. But the fact that some purchases were approved while some were commented upon adversely leaves absolutely no room for such misunderstanding.

If the duplicate samples of such standards, against which the supplies were compared, were really superior, all the purchases made should have met with the same fate. But since this was not the case, the only inference that can possibly be drawn is that the failure of the Joint Mica Mission to achieve success in this respect makes a prima facie case that a quality standardization of mica is neither practicable nor acceptable to the consumers.

These discrepancies can be explained perhaps by the personal equation involved in the quality sorting and inspection of mica, on the one hand, and the varying nature of the consumers' requirements, on the other. It is also a fact that some difference of opinion always existed. But as such difference should always be confined to a margin of 10 to 15 per cent at the most, this personal element cannot adequately account for a delivery being declared 50 per cent substandard, especially when it is accepted after a thorough inspection by the government inspectors in India, who have been, I am proud to be able to say, absolutely impartial and above reproach in all dealings with the Indian mica suppliers.

The above discussion on both views gives rise to the following issues.

1. Why is it that only in the case of purchases made through government organizations, against fixed standards, has the quality

of the bulk purchased been disputed so frequently by the consumers?

2. Why are such disputes rare when business is done directly between Indian exporters and buyers abroad?

In normal times, business is negotiated between a party in India and a party in a foreign country, in an atmosphere of mutual understanding created by long connections. The amount of tolerance that should reasonably be allowed in making and accepting deliveries against a certain standard mutually agreed upon between the buyer and the seller is well established and thoroughly understood by both parties. Usually neither side tries to exceed such limits of tolerance out of respect for a hard-earned mutual confidence, which ultimately leads to a very smooth and happy continuation of the business relationship.

Moreover, when transactions are directly between two parties, without government interference in quoting prices or submitting samples, a fair margin is kept by the supplier to cover the little amount of extra sweetening of the bulk supply, which has essentially to be made as a provision against the vagaries of the personal element and to preserve one's good will and credit, which is after all the backbone of any trade or industry.

Besides, the freedom that the consumers enjoy in picking and choosing a particular standard of a particular supplier, which can suit his requirement best, is a very important consideration. But in the case of purchases made through government agencies against fixed standards, this freedom is completely lost, and the buyer, under compulsion, has to take what is supplied him and has ultimately to adjust himself to fixed standards over which he has no control or else be prepared to suffer grave inconveniences.

Moreover, in the case of purchases made through government agencies (under controlled conditions and at the low prices arbitrarily and habitually fixed by such agencies) all considerations of credit or good will completely lose their importance and are no longer respected. The responsibility of the supplier ceases the moment the supply is accepted by the government inspectors. Besides, the fixation of prices against government standards impels the supplier to stick to the bare minimum in regard to quality, as there is no premium to be had if the quality supplied exceeds the specified standard.

The prices fixed by the Joint Mica Mission were in fact appreciably lower than they should have been, with due consideration to the increased cost of production and a number of other factors, which had most unfortunately been ignored. In the circumstances, the industry in general had no other alternative than to stick to the bare minimum, as far as the quality of the supply was concerned. On the other side, too, when the buyers came to inspect such purchases made by government agencies against fixed standards, they were only concerned with picking up the best from the lot, and to pay no regard to the limits of commercial tolerance. Moreover, if the government standard did not fit in with his requirements, the buyer became too critical. For example, if he wanted heavily stained from the government stock and found that it was much inferior to what he had been buying from his supplier in peacetime as heavily stained, he declared it substandard, irrespective of what might have been the standard against which purchases were made. A situation was thus created in which criticism was bound to be more or less inevitable. It cannot be otherwise under government control of mica marketing.

A short discussion on the quality classification of mica will afford a clearer understanding of this subject. Though nomenclatures are fixed for all the qualities of mica, the fact remains that it is practically impossible to describe the quality of mica literally to serve any useful purpose.

Attempts have however been made by certain authorities to describe literally the various commercial qualities of mica. The following is the description prepared by Dr. J. A. Dunn, of the Geological Survey of India, in consultation with Mr. R. A. Hart, a technical member of the Joint Mica Mission.

Quality	*Classification*
Superfine..........	The mica must be hard and optically flat. It must contain no stains or flaws of any description.

Quality	*Classification*
Clear & S.S.	The mica must be hard and substantially flat and free from cracks. The largest rectangle obtainable must be free from mineral inclusions and stains but may contain small air stains within a small part of the rectangle.
Fair stained	The mica must be hard and free from cracks but may be slightly wavy. The largest rectangle obtainable may contain some small air stains and within a small part of this area may contain small light stains.
Good stained	The mica must be hard and free from cracks. It may be wavy but not buckled. It may contain air stains throughout and may contain light stains and heavier stains or mineral spots around the edges.
Stained	The mica may be fairly hard and may be wavy and slightly but not badly buckled. It should be free from cracks. The mica may contain stains and small mineral inclusions on the edges and heavier stains over a small part of the area.
Heavily stained	The mica may be slightly buckled. It may contain heavy stains and mineral inclusions over part of the area.
Densely stained	The mica may be partly buckled and may contain dense stains and scattered mineral inclusions.
Silver stained and white	The same as stained, but air stains may be of such a pervading character as to impart a silvery or white appearance to the whole surface.
Dotted	Quality as for good stained but with isolated black dots throughout.
Densely stained and spotted	As for densely stained but with heavy spots and mineral inclusions.
Black spotted	Hard flat mica with spots and streaks and with mineral inclusions throughout, the spots and streaks not to be generally red in color.
Red spotted	As for black spotted but the majority of spots and streaks are red.

The above descriptions give the quality designations adopted by the mica trade in general, with a brief description of the characteristics corresponding to each term. But the following definitions, employed in the standard specifications of the American Society for the Testing of Materials and using similar descriptive terms, differ appreciably from the joint description of Dr. Dunn and Mr. Hart.*

Quality	*Classification*
Superfine	Free of all mineral and vegetable inclusions, stains, air inclusions, waves, or buckles. Hard transparent sheets.
Clear & S.S.	Free of all mineral and vegetable inclusions, cracks, waves, and buckles but may contain slight stains and air inclusions.
Fair stained	Free of mineral and vegetable inclusions and cracks, hard. Contains slight air inclusions and is slightly wavy.
Good stained	Free of mineral inclusions and cracks but contains air inclusions and some vegetable inclusions and may be somewhat wavy.
Stained	Free of mineral inclusions and cracks but may contain considerable clay and vegetable stains and may be more wavy and softer than the better qualities.
Heavily stained	Free of mineral inclusions but contains more clay and vegetable stains than that of stained quality and distinctly inferior as regard to rigidity and toughness.
Black stained and spotted	Apt to contain some mineral inclusions consisting of magnetite (black), specularite (red), and hydrous iron oxide (yellow).

The description of the item clear (superfine) is in both cases practically identical. But in the case of Clear & S.S., the former authority desires it to be substantially flat and wants an absolute freedom from mineral inclusions and stains in respect to the largest rectangle obtainable. According to the latter authority, however, it must be absolutely free from waves and buckles, although it may contain slight stains. Since vegetable, mineral, and air inclusions have been mentioned separately, it is difficult to understand what the term "slight stains" is meant to convey. Again, the latter makes a general statement allowing slight air inclusions, whereas the former makes this allowance conditional and limits the presence of small air stains to a small part of the largest obtainable rectangle. Hence, in so far as allowances for this particular quality are concerned, these authorities differ from each other considerably.

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* In the classification of qualities of Dr. Dunn and Mr. Hart, we find a few more qualities, such as silver stained and white, dotted, densely stained and spotted, which are not included in the A.S.T.M. classifications of qualities. These are the products of only a few mines, and since the quantity produced is very small, the classification cannot possibly be generalized.

Now coming to the next lower quality, fair stained, the former says that the largest rectangle obtainable may contain some air stains, and within a small part of this area it may contain small light stains. According to this description, there is a marked difference between the next higher quality, Clear & S.S., and the quality fair stained. But according to the latter authority there does not seem to be any appreciable difference between these two qualities, save that fair stained may be slightly wavy. On the contrary, and in spite of its being the next lower quality, no mention has been made in the description in respect to the inclusion of slight stains being permissible, though in the case of Clear & S.S. some tolerance has been allowed for this defect. This is very curious, for since this is a lower quality, one would naturally expect a higher allowance. Here again there is no coincidence between the descriptions of the two authorities.

Coming to good stained, according to the former it may contain air stains throughout. The statement in respect to air stains is absolutely unqualified, for it does not put any limit whatsoever to the amount of air stains that it may contain. But according to the general trade practice, the presence of air stains beyond a certain limit prevents a piece from being included in this quality. Moreover, there being no mention about air stains in the next lower quality, stained, by both authorities, one assumes that any amount of silver stains is tolerable in this particular quality, unless the stains are of such pervading character as to impart a silvery or white appearance to the whole surface and thereby place it in the new category of silver stained. This, however, is absolutely erroneous.

A piece of mica may have the highest degree of both hardness and flatness and may be absolutely free from any kind of mineral or vegetable stains, but if it contains silver stains beyond a certain limit, it must be classed as stained quality. In fact, fairly hard pieces with heavy air inclusions constitute a substantial portion of the bulk of stained quality mica of a reasonable standard. Apart from the degree of hardness and flatness and since the inclusion of both vegetable stains and mineral stains is restricted to certain rigid conditions that limit their presence either around the edges or on a very small part of the largest rectangle obtainable, it is, in the final analysis, the presence of air inclusions in varying degree that really decides the quality of stained and better quality mica.

Again while speaking of the inclusion of heavier stains or mineral spots in good stained quality, the former authority limits their presence to around the edges, while the latter prohibits the inclusion of mineral stains altogether and, in respect to air inclusions and vegetable stains, just makes a general statement without imposing any condition whatsoever.

The most serious discrepancy is in the next lower quality, *i.e.*, stained. According to the former standard, in addition to its being wavy, it may also be slightly buckled and contain stains, although the stains and small mineral inclusions are permissible on the edges only, while over a small part of the usable area some heavier stains are also tolerable. But the latter standard, while giving no allowance for mineral inclusions and buckling, allows a considerable inclusion of clay and vegetable stains unconditionally.

Similarly, in other qualities as well, both authorities will be found differing considerably from each other in their conception of the various qualities of mica.

However, apart from a considerable difference at each point of the above descriptions by both authorities, the expression of the characteristics in comparative terms makes the final decision strictly a matter of opinion. For example, while talking of the degree of flatness for various qualities, it has been said that pieces belonging to a lower quality may be comparatively more wavy than those belonging to the next higher quality, or as regards stains or air inclusions it has been said that some quality may contain heavier stains or air inclusions than the other in the larger part of the area or the smaller part. But nothing definite has been said in respect to the maximum and the minimum permissible limits and their measure. Hence, no quality assortment of any bulk can be practically based on the above descriptions, for, beyond giving a vague comparative idea, such descriptions fail to give enough data for setting up a standard correctly.

Moreover, from the above descriptions a layman is likely to infer that all pieces belonging to the bulk of a particular quality may contain all the defects within permissible limits and are more or less identical, as is the case with any other commodity described as belonging to a particular quality. But it is not the case with mica, where the description of a certain quality of a particular standard suggests a range between the maximum and the minimum tolerable defects. If a certain piece is found with more than two such defects, it has usually to be discarded into the next lower quality. For example, if a piece of mica, in addition to being slightly wavy, contains minute air bubbles and slight stains, it may not be regarded as fair stained, or if all the pieces belonging to a particular bulk, in spite of being reasonably flat, contain minute air stains and/or light stains, even to a tolerable extent or vice versa, the bulk cannot be called a good delivery of fair stained. Generally a good delivery of fair stained, as described by Dr. Dunn, should contain a percentage of reasonably flat pieces with minute air bubbles, a proportion of slightly wavy pieces with no other defects, and some proportion with slight stains.

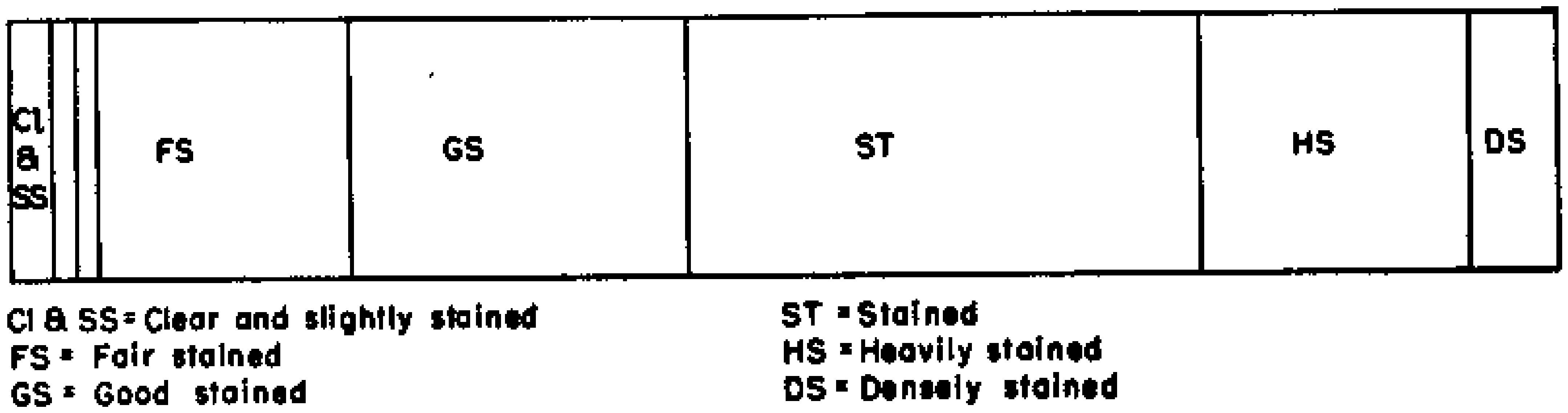

FIG. 56*A*. A hypothetical grouping of mica quality samples of a particular standard, explaining how the bulk supply of a particular quality can be further subdivided into a number of groups, depending on the various defects permissible within certain limits mutually agreed upon between the buyer and the supplier.

To understand this better, let us study the quality samples of a particular standard, represented graphically by Fig. 56*A*.

Now according to the accompanying illustration, a standard sample of Clear & S.S. may consist of, say, 50 per cent reasonably flat pieces free from any silver specks or very minute air inclusions, vegetable stains, or any other metallic specks; 25 per cent very slightly wavy, but free from any other defects enumerated above; and 25 per cent reasonably flat but with a few minute silver specks or air stains. Similarly all the other qualities may be further subdivided into different groups with varying degrees of defects within permissible limits.

But while sorting a bulk according to the above standard, it is practically impossible to adhere strictly to such proportions. For example, instead of 50 per cent being reasonably flat and free from all other defects in a bulk of Clear & S.S., there may be 40 per cent of the same with a proportional increase in the other two subdivisions or in only one subdivision.

This is mainly because the quality and the nature of the product of different mines, in respect to the physical characteristics that are taken into consideration in quality assortment of mica, differ considerably from each other. Hence the average product of a particular mine or a group of mines of a substantial producer may not, on quality assortment, yield a bulk that will accurately conform to the various qualities of a fixed standard. Hence, it is absurd to expect the product of various firms to conform to any fixed standard to a degree that would eliminate all chances of controversy. Even if one tries to sort a bulk of S.D.B. according to the various subdivisions of different qualities and then prepare a final bulk of a particular quality by mixing all its constituents in the proportions found in the standard sample, one will in most cases fail to obtain absolute concurrence. Besides, the sorting of a bulk, as suggested above, into various subdivisions of all the qualities is economically absurd.

In the usual course of business one should take the average run of available S.D.B. from a mine or a number of mines and sort all the qualities from the same with the available proportion of each subdivision of a particular quality. If, of course, while sorting a particular quality from such bulk, with a view to getting an increased production of the same, one includes pieces that are just below the borderline separating it from the next lower quality, the quality of the bulk thus assorted is naturally reduced. But some amount of overlapping between the next lower and the next higher quality is almost unavoidable and is the chief attribute of the human equation. In the case of overlapping between a particular quality and the next higher one, it sweetens the bulk a bit, which again is neutralized by the overlapping of the next lower quality, in case it is in somewhat similar proportion; or else the bulk is rendered inferior, the degree of which depends chiefly on the amount of such downward overlapping.

It is as a result of this natural handicap that the judgment of the quality of mica is largely a matter of opinion. Besides, such judgment is considerably influenced by the natural light available at the time of inspection and the mood of the inspector. For example, if a case of mica just up to a certain standard is examined in cloudy weather, the entire bulk looks very dull, which affects the first impression of the inspector adversely. Added to this, if the inspector is not in a good mood for some reason or other, the delivery stands greater risk of being rejected, provided, of course, the material is not urgently needed. It was often observed during the Joint Mica Mission days that a particular delivery rejected by an inspector was accepted by the resident member of the mission, or if redelivered after 2 or 3 days it was accepted by the same man who rejected it.

However, in spite of the best efforts of a supplier to make a reasonably good delivery against a standard mutually agreed upon between the buyer and the seller, if there is a controversy in respect to the quality of the product, it can be attributed only to the human element involved throughout the entire process, beginning from the quality assortment to the final inspection by the buyer, which again is solely dependent on a subjective estimate. However careful a supplier may be in the final packing of a consignment, if the buyer is bent upon getting a rebate, he can easily manage to find fault with it. In the final analysis of the problem, it is market demand and the good will of the buyer (assuming a reasonably good delivery) that decide the intensity of such disputes. If the inspection is made by the buyer with an honest intention to accept a consignment if it is good enough, he is sympathetic to the supplier and, unless there is something seriously wrong, he is prepared to overlook flaws in unimportant details. But in case such buyer is by nature prone to faultfinding, no consignment can survive inspection. Some degree of dispute will always arise, and it is aggravated when demand is slack or circumstances are otherwise unfavorable.

Again, the descriptions of qualities drawn up by the aforesaid two different authorities clearly indicate how the conception of the qualities of mica differs considerably with different countries, for the former description was prepared in consultation with an English authority, while the latter comes from the United States. Apart from this difference, which always exists between any two countries consuming mica, this conception and specification of qualities differ even from consumer to consumer in the same country, according to the nature of their requirements. It is as a result of this that, from the very inception of the mica industry, different exporters have been doing business on different standards of their own, and the product of a particular producer or exporter has always been finding preference from a certain group of consumers. The establishment of government control over standards and marketing of mica will destroy this mutually acceptable basis.

No doubt it is confusing to a layman as to what is really meant by this much discussed difference in the quality standards of various concerns.

Apart from the color variation, such as ruby, green, or brown, on which depends the primary qualification of mica, the secondary classification of a bulk, belonging to a particular group, into its various commercial qualities depends mainly on its various natural defects, and, as has already been explained, a particular quality denotes a specific range of the maximum and minimum defects tolerable in that quality of a particular standard.

The difference between the quality standard of Mr. A and that of Mr. B producing the same type of mica (so far as the basic color is concerned) is in short the difference of range only, as is clearly represented graphically by Fig. 56*B*.

According to the illustration, all the qualities of Mr. A begin from a higher level, with the exception of the highest quality, which has a much shorter range than that of Mr. B, though commercially, as far as nomenclatures are concerned, they are the same in the case of both Mr. A and Mr. B. Mr. A's quality being superior to that of Mr. B, his goods certainly get a higher price than that of Mr. B, and if the increase in the price is quite proportionate to the superiority of the quality, both these gentlemen get the same price for the bulk in the average. But in practice, it is absurd to make such proportionate calculations. The whole thing depends upon how far one standard meets the requirements of a particular buyer.

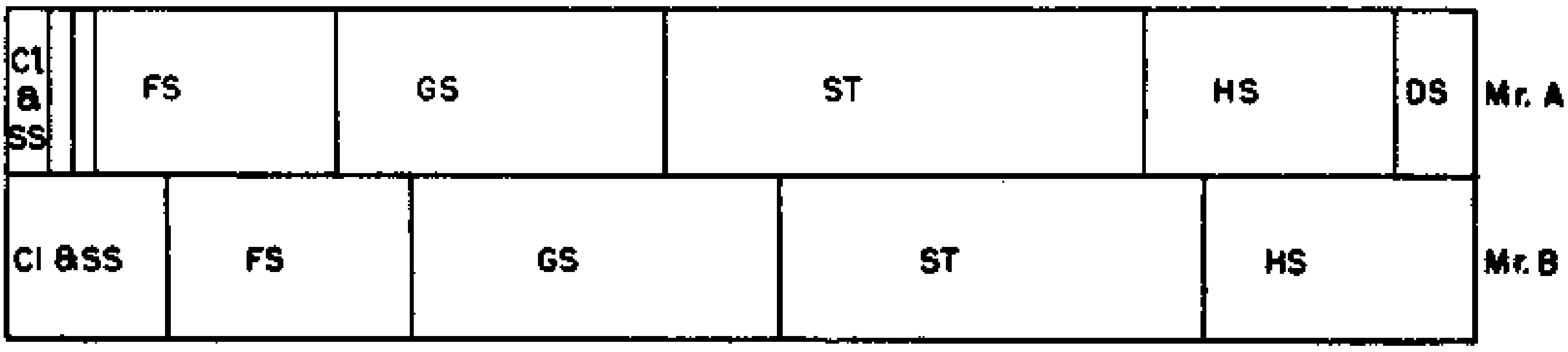

FIG. 56*B*. A hypothetical grouping of mica quality samples of two different standards, explaining the difference between them.

Now the point is that Mr. A has a fixed standard and can sort any bulk given to him according to his own standard. It may be possible that, if it pays him to do so, he can easily sort the same bulk to Mr. B's standard as well, and the same thing can be said of Mr. B. But the most important issue arising out of this is whether Mr. A's standard will suit Mr. B's consumers, and vice versa. If a particular consumer has the standards of both Mr. A and Mr. B, before placing his order for a particular quality of mica, he tries to find out whether Mr. A's range of a particular quality will suit his purpose, and then his purse, better than that of Mr. B or Mr. B's better than Mr. A's. It is only after deciding this that he chooses what he considers to be the better of the two, depending mainly on the minimum waste or by-product with maximum economy, and places his order.

Considering the purchases made by the Joint Mica Mission against certain standards during the war years, one might argue that standardization has been made possible, since all the consumers of the United Kingdom and the United States were getting their requirements from only one source and against fixed standards.

But it must be borne in mind that peacetime requirements cannot be controlled in the same way or to the same extent as wartime requirements. Domestic electrical appliances like heaters, irons, electric kettles, stoves, radios, fans, etc., play a very important part in the consumption of mica, especially the bulk of it, which predominates in the lower qualities. The manufacture of such appliances has to suit the taste of both the rich and the poor. A particular manufacturer limits himself to the production of expensive appliances intended for the wealthy. Another manufacturer designs and produces such appliances to suit the means of middle-class families; while the third devotes his energy to satisfying the ambitions of the poorer classes. One engaged in the manufacture of high-class electrical appliances may go in for the standards of Mr. A, since the range provided by those of Mr. B begin from a very low level; and if he must buy from Mr. B he must either reduce the quality of his products or must find a buyer for the by-product, while sorting his requirements out of the bulk supplied by Mr. B. Such undesirable by-products give rise to a lot of complications in the management, and one would gladly pay a little higher price to get Mr. A's standard rather than be left with a considerable amount of by-product, even if Mr. B's product is made available to him at a lower price.

Similarly, in the case of a consumer preferring Mr. B's standards, if he is forced to buy from Mr. A, either he must use the entire bulk, which will always be in excess of his requirements, ultimately increasing the cost of production, or he must sort a portion of the superior mica out of the bulk and sell it at reasonable prices to even out his cost of production. In this case, also, Mr. B's buyer will always prefer paying a slightly higher price to Mr. B for his standard, for it leaves him with no appreciable quantity of by-products and saves him the bother and cost of sorting the bulk to his specification.

Under the circumstances, it is a matter for serious consideration whether it will suit the needs of all the consumers of the world to bring Messrs. A and B or C, D, E, etc., together and take the average of all those parties' standards for the purpose of standardization of quality.

The problem could probably be alleviated to some extent, from a technical point of view, if the consumers could possibly state their requirements in terms of electrical properties of mica required for various specific purposes and if, at the same time, it could be made practicable to effect the quality assortment of mica with the help of electrical devices according to the buyers' specifications. This might reduce the personal equation to a negligible minimum and allow a producer or processor to supply the exact requirement of his buyer so as to leave no undesirable by-product.

The following information obtained from the article entitled "Saving Mica by Testing," by Mr. M. G. Coutlee,* indicates that the quality classification of mica with the help of electrical instruments on commercial scale has been made practicable.

With the war appeared a colossal demand for capacitors or condensers, calling for the supply of high-quality mica in huge quantities. The government of the United States began envisaging the serious shortage of such high-quality mica (which represents a very small part of the total production), especially in view of the enormous demand for it on the one hand and the wartime transport difficulties on the other. Among the large number of devices using mica, none is more exacting in point of quality than the capacitors used in large quantities for all types of radios and wire communication circuits. For the better grades of such capacitors, the mica must not only be free from all defects such as cracks or conducting spots, but must have very low dielectric loss and must be able to undergo wide temperature cycles with only minor changes in characteristics, which must always be the same over repeated cycles. In the absence of any electrical apparatus that could commercially be used for determining these required properties with desirable speed, the entire test was dependent on eye estimation. The result is that, to make sure of all the required characteristics, only the better ruby muscovite micas could heretofore be accepted for the production of satisfactory capacitors. But it was by no means certain that some and perhaps much of the mica that was rejected by visual test might not have been found equally suitable. Nor was there a satisfactory proof for condemning the other types of mica that might also yield appreciable quantities answering the electrical demands.

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* *Bell Laboratories Record,* Vol. 23, No. 13, 1945.

These useful possibilities, plus the threatened shortage of high-quality mica, led the War Production Board of the United States to appeal to the Bell Laboratories in the fall of 1942 to devise a method of testing and classifying mica that would give more positive results.

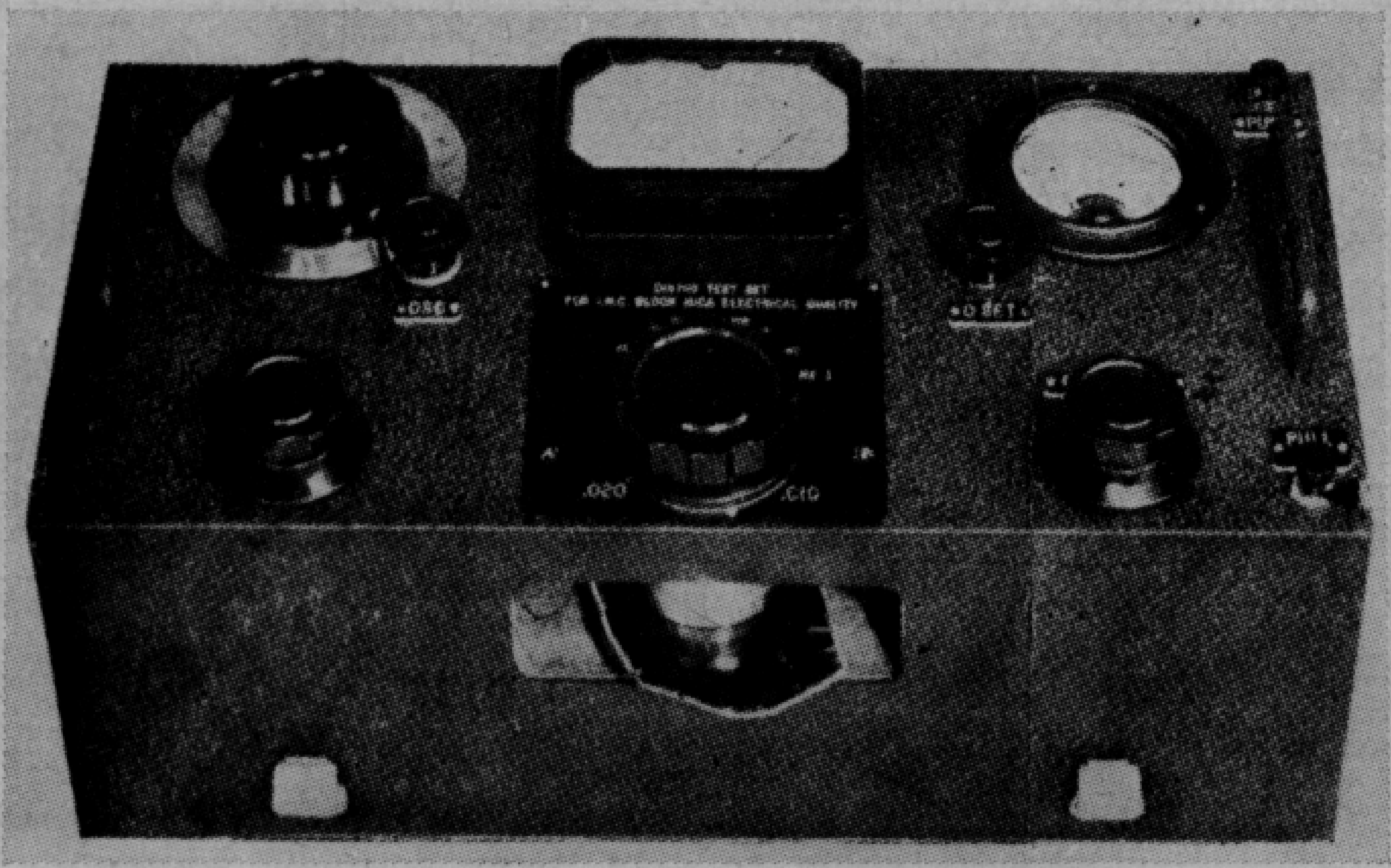

FIG. 57. This portable, self-contained, battery-operated, direct-reading instrument incorporates an oscillator for determining the power factor of block mica for condenser use at a frequency of 1 megacycle. (Source: *Bell Laboratories Record,* Vol. 23, No. 13.)

Such tests and classifications were required not only for ensuring the use of the right type of mica for the finished capacitors, but also to avoid the rejection of good-quality mica. Apart from all the various characteristics that make mica one of nature's most useful curiosities, its dielectric constant shows relatively little variation, since it depends on the basic chemical substance, which is essentially the same for all types of muscovite mica. Some micas are rendered inferior either because of physical defects like cracks, pin pits, waviness, or cross grains or because of the inclusion of conductive minerals seriously affecting the dielectric strength. But all such defects are detectable visually. What was urgently needed was the quick and easy method of detecting conducting regions and for determining the dielectric loss under the influence of the alternating voltages the mica would encounter in service. To cater to these needs, the Bell Laboratories undertook an investigation that culminated in the design of two test sets, one to detect conducting regions and one to measure the dielectric loss of block mica.

The test sets for determining the dielectric loss (Fig. 57) measure the power factor of the current flowing through mica when high-frequency voltage is applied across it. Since ordinary methods of measuring power factors are too slow for commercial tests of this type, a circuit was designed that gave a suitable measure of the loss as a single reading of a voltmeter, with the help of such a set. It was made possible to test as many as 15 samples of block mica per minute, even for capacitors operating at frequencies of the order of a million cycles.

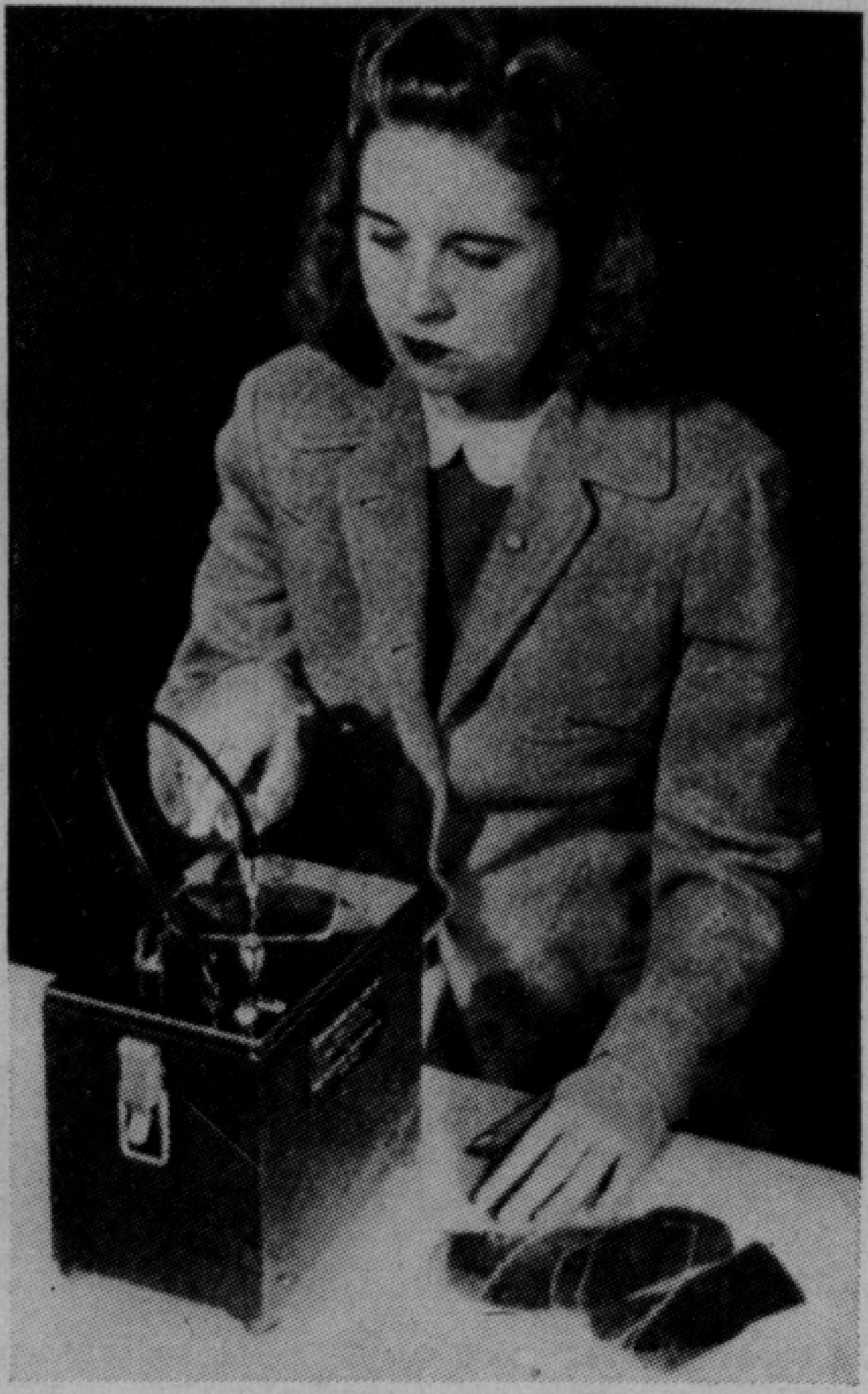

FIG. 58. An electrical instrument designed to detect conducting regions in a mica piece. (Source: *Bell Laboratories Record,* Vol. 23, No. 13.)

The set designed to discover conducting regions in stained mica (Fig. 58) prior to the power-factor test has also proved equally reliable and efficient. A sheet of mica is placed on the test plate and the test point is moved over its surface. Any defective regions that may be there are indicated by sparkings at or in the vicinity of the point. Only a few seconds are said to be required for each test, and it has further been claimed by the makers that, by the use of these two test sets, a large quantity of muscovite block mica rejected as unusable for capacitors through visual tests was accepted and used in about 40,000 capacitors by several manufacturers. These capacitors fully met thorough performance and life tests made by manufacturers and proved the reliability of the test-set classification. The most useful part of this invention is said to be that, as a result of this commercial trial, an increase of about 50 per cent in the muscovite mica suitable for use in capacitors has been realized. With the investigations that were in progress, it was hoped that this figure may ultimately be increased to 60.

In view of the practical utility of such tests established by the successful use in 40,000 capacitors of mica that according to the visual test had been discarded as unusable, especially in appliances like condensers, calling for the use of high-quality mica, it must be admitted that from the point of view of conservation the popularization of the above test sets is of extreme importance. The tests alluded to above, however, are applicable only to mica required for use in condensers, which represents only a very small percentage of the total production of mica.

Besides, even in the above case it is perhaps impossible to dispense with subjective tests completely. The detection of defects like undesirable cracks, buckled or wavy pieces, etc., has to depend on visual examination, and a thorough test to guarantee the perfection of a bulk supply will always have to combine both the subjective and the objective tests.

Hence, in the circumstances detailed above, the idea of the complete elimination of the human element from the quality assortment of mica is absurd, and so long as India or any other mica-producing country continues to supply mica to consumer countries in semicrude form, no practicable solution of the problem of the quality standardization of mica can be had.

In view of all the handicaps enumerated in the foregoing pages, if attempts are now made to fix and enforce quality standards, it will be seriously detrimental to the interest of the whole Indian mica industry, for it will encourage consumers to give preference to the products of other countries, where they will enjoy the freedom of picking and choosing their requirements from an uncontrolled market. Besides, to ensure the proper adoption of fixed standards by the Indian mica trade in general, all outgoing consignments of mica will again have to be inspected by a competent inspectorate, which again will lead to the unfortunate repetition of the history of the Joint Mica Mission method. But above all, it can never be made obligatory to the foreign consumers to accept the decision of such inspectorate.

CHAPTER 10

Marketing of Mica

The marketing of mica can be discussed under two divisions, (1) domestic marketing and (2) foreign marketing.

Because domestic consumption amounts to virtually nothing, domestic marketing is confined to dealings in mica amongst the various members of the trade and is generally limited to sales of mixed-quality S.D.B. of practically all sizes and No. 6 loose splittings. Little business is done in block mica sorted according to different qualities or manufactured materials like condenser films, wrappers, etc. Since there is no fixed standard, the prospective buyer goes to the dealer's shop, inspects the mica, and roughly estimates the value, and in case they come to mutual agreement on price, the transaction is closed there and then, and delivery is taken immediately.

This type of local dealing is as speculative as mining, because when purchases are made in the local market, an estimate must be made right on the spot on the expected recovery of different qualities of marketable block mica from the mixed-quality bulk of any grade, as well as the percentage of undersize. The entire estimation depends on visual examination, and a great deal of experience and judgment is required. Lack of experience in this marketing practice has proved disastrous to many concerns in the mica field, especially to newcomers who are attracted by the periodical booms and give little thought to the peculiar features of this industry and trade.

Japanese air raids over Calcutta in 1942 led to an influx of many businessmen from Calcutta into the mica-manufacturing centers, where well-known sanatoria are also located. Many of these unemployed businessmen entered the mica trade. Unfortunately, hardly any of the newcomers could become established in the trade for lack of experience. Most of them sustained heavy losses and ultimately had to quit the field. It can even be said that people with experience in this line are by no means infallible in purchasing mica from the local market. In many instances at least 25 per cent of their total transactions generally prove to be unprofitable.

Before World War II the principal foreign markets were

1. London for the United Kingdom and the European continent.
2. New York for the United States.
3. Genoa for Italy.
4. Hamburg for Germany.

In pre-war years, Japan accounted for a considerable take of Indian mica. In that country the mica business was scattered among many centers, the larger ones being Tokyo, Yokohama, Osaka, etc.

Mica was exported to these foreign markets in three different ways, which are described as follows:

1. The larger producers of mica used to hold stocks in the principal foreign markets mentioned above at the disposal of their appointed agents in these places. Though Japan was also an important buyer, the writer is not aware of anyone's having maintained any stocks of mica in that country. Where stocks of mica were maintained, they were entrusted to the care of banks in the different places and were delivered against full payment under the agents' instructions after sales had been closed between the agents and the buyers. The agents were vested with the necessary discretion regarding prices. Facilities for inspection of merchandise were, of course, afforded to buyers before closure of any transaction. About 50 per cent of the total export of mica from Bihar went to supplement such stocks in the foreign markets.

2. Considerable quantities of mica were also exported against firm orders from foreign buyers consisting mainly of brokers, middlemen or dealers, and, in a few cases, consumers. Prior to World War II, payments in most cases were made by the foreign buyers only after the exported bulk was examined and approved by them.

3. Considerable quantities were also exported against 80 per cent or 100 per cent letters of credit, mostly irrevocable, opened by the foreign buyers with a reputable bank in India to be negotiated against a full set of shipping documents. In the case of 80 per cent

credits the balance was remitted by the buyer after inspection and approval of the ordered materials.

The London market was considered the most important mica market, from which the rest of the world drew its supplies, though direct purchases from India were also made by the various consuming countries. In the London market there were brokers who negotiated business between the consumer and an Indian exporter and took a certain percentage of the sales as commission. Besides these brokers, there were importers, mostly agents of the principal Indian producers or their organizations. Very few producers had direct contact with the ultimate consumers.

In the United States there were practically no such brokers as in the London market, and the mica trade was mostly confined to importers who bought mica at a certain price from the Indian market and sold it to the consumers. Since such dealers did not work on a commission basis, they sold the imported products at a profit. This system of dealing in mica was prevalent in Japan as well, whereas both in Italy and in Germany a few brokers did business on a commission basis.

The exigencies of war conditions, as they were viewed and understood by the authorities, called for changes in this system of marketing. In 1940, therefore, the director of the Geological Survey of India started purchasing surplus mica from the Indian market for the United States government, as has been pointed out in the preceding chapter. Since the purchases made by the director were of surplus mica, there was practically no restriction on the export of mica to allied or neutral countries by private parties. Nor were the prices arbitrarily fixed. Tenders were invited from the trade against fixed standards with samples. After the approval of the trade sample by the government mica inspector, the lowest quotations within certain limits used to be accepted. Originally, the trade was required to deliver the materials ordered at the Kidderpore docks, where the government mica inspector examined the bulk and, if the goods were found acceptable, issued a certificate of acceptance, on the receipt of which bills were submitted to the director general of Munitions Production through the director of the Geological Survey of India. Prior to being forwarded to the director general of Munitions Production, such bills were attested by the government mica inspector, and, on receipt of the bills, the director general of Munitions Production would make full payment at the earliest opportunity.

This system of purchase continued up to the third quarter of 1942, when the Joint Mica Mission came into existence. The quality standards and prices for blocks, splittings, and condenser films were fixed by the Joint Mica Mission. The most remarkable feature of this new system of purchase was that the trade was not consulted at all on any matter. The basic prices fixed were much lower than either the ruling market prices or the prices paid by the Geological Survey of India. As a consequence, there was considerable agitation in the trade. But unfortunately, since the prices were approved by a small but influential section of the trade, the agitation gradually subsided. With a view to pacify the trade, an appreciable tolerance was used by the Joint Mica Mission in accepting deliveries, which was further supplemented by counteroffers for substandard deliveries. Such counteroffers were always to the advantage of the suppliers. Added to this was the placing of large orders for some special requirements, especially wrapper splittings, at attractive prices, which ultimately eased the tension to a considerable extent. The heavy demand for wrapper splittings enabled a better recovery of value for the average production of mica, because it found a consumption for practically the entire bulk of No. 4 and up, stained quality block mica. Such stained quality mica used for the manufacture of wrapper splittings constitutes a somewhat valuable part of the average production from a mine.

All these extra facilities granted to the industry in their cumulative effect compensated the trade appreciably, though not fully. After about 6 months (March, 1943) the Joint Mica Mission gave a cost allowance of 15 per cent to the trade over the mission's scheduled prices. This was announced in August, 1943.

In the middle of 1943, when the food situation became very acute and the price of rice, the staple food of the labourers, shot up from about Rs.8/- ($2.43) to Rs.30/- ($9.13) a maund (82¼ lb.), the Joint Mica Mission undertook to supply the trade's requirement of rice at a fixed price of Rs.13/5/- ($4.05) a maund. The trade was partly compensated by the Joint Mica Mission in supplying the rice to the labourers at a normal price of Rs.9/– ($2.74) to Rs.10/– ($3.04) per maund. This arrangement continued till the end of 1943. Because of difficult circumstances arising out of the war, especially with regard to food and cloth, the cost of production increased rapidly. The Joint Mica Mission was again approached by the trade for a further increase in the cost allowance by 35 per cent, thus making a total of 50 per cent. It is worth noting in this connection that a section of the trade, which approved of the first low basic prices of the Joint Mica Mission, took the initiative in agitating for such increases and went to the extent of entering into acrimonious correspondence with the Joint Mica Mission. This suggests that behind the original approval of the basic prices of the Joint Mica Mission there lay some deeper motive.

After a fairly long discussion, the Joint Mica Mission appointed Messrs. Price, Waterhouse, and Peats, chartered accountants, to look into the accounts of a few principal concerns to ascertain the actual increase in the cost of production, and on receipt of a report from them (which was not revealed to the industry), the mission gave an increase of 27½ per cent in the cost allowance, thus making a total of 42½ per cent, which was announced in January, 1945, retroactive from May, 1944. The trade had requested the increase be made retroactive from January, 1944.

It was thought that the Joint Mica Mission gave a rather queer explanation that the increase become effective in May, 1944, merely because the trade moved the Joint Mica Mission for such increase in May, 1944. However, practically speaking, this increase of 27½ per cent meant very little relief to the industry; for, prior to giving this relief, all the special orders were withdrawn and the inspection of deliveries by the Joint Mica Mission inspectorate was made stricter and it was further tightened after the declaration of this 27½ per cent allowance. Thus the tolerance which had been allowed for practically 2½ years was suddenly and completely withdrawn. This strictness, coupled with the withdrawal of the special orders, amounted to the Joint Mica Mission's taking away with the right hand what it gave with the left. It is true that it was a great advantage to the industry to have a buyer for the whole of its output practically at its doorstep, particularly in view of the difficulties in securing shipping space under war conditions, and the Joint Mica Mission would have proved immensely beneficial to all concerned if it had taken a broader view at the very beginning in making purchases and had functioned in full cooperation with the trade. But unfortunately, not only was such a cooperative spirit virtually absent, but there was always a dictatorial attitude on the part of the mission. This attitude, coupled with a low-price policy in the face of rapidly rising costs and the sudden clamping down of stricter inspections, affected the trade seriously, as was evident from the marked fall in mica production. This occurred in spite of the good efforts of a separate department, known as Stores and Purchase Section, set up by the government of India under the Geological Survey of India to assist the mica industry in procuring machines, petrol, coal, and all other materials required for mining operations. However, the best efforts of the mica industry to explain and point out its problems and to secure redress virtually ended in complete failure.

What still remains a mystery to the Bihar mica trade is why the Joint Mica Mission adopted and pursued a low price policy for an "all-out" purchase of strategic Bihar mica on one hand, whereas, on the other, prices for other strategic materials that contributed to the cost of fighting the war were permitted to become established at higher levels. Though mica was strategic during the war as a component part in electrical equipment, the value of the total quantity of mica used may be compared to a pinch of salt to a good dinner. Moreover, a comparison of the prices paid for Bihar mica with those paid for Madras mica by the same body further enhances the element of mystery. Bihar mica is undoubtedly the best mica in the world, but the prices paid by the Joint Mica Mission for Bihar mica were 30 per cent to 40 per cent lower than those paid for Madras mica.

A comparative study was made by Mr. E. Watson of Messrs. F. F. Chrestien & Company and the author at Madras in the Joint Mica Mission inspectorate. An analysis of the standard sample of Madras ruby No. 4 AQ according to the Bihar standard revealed the results shown in the following table.

11 pieces corresponding to the stained quality of Bihar..................	3¾ oz.	70%
6 pieces good stained................	1 oz.	20%
3 pieces fair stained.................	½ oz.	10%

The value that a bulk lot of No. 4 AQ ruby would yield if sorted according to the Bihar standard was calculated and it was found that the average bulk would fetch Rs.6/6/- ($1.94) per pound, whereas its price was fixed at Rs.8/2/- ($2.48), a difference of 28 per cent in favour of Madras.

Another Madras standard sample of the Joint Mica Mission termed as ruby BQ No. 4 was also analyzed; and according to the Bihar standard the entire bulk with the exception of one piece only was heavily stained. The price fixed by the Joint Mica Mission for this bulk was Rs.6/4/- ($1.90) per pound, while the price paid to Bihar was Rs.3/4/- ($0.99) per pound for practically the same mica, thus leading to a difference in this particular case of Rs.2/12/- ($0.84), *i.e.*, over 40 per cent in favour of Madras.

The analysis of the third sample known as green BQ No. 4 also showed similar results. Leaving aside the color, the analysis on the consideration of defects alone showed 75 per cent heavily stained according to Bihar standard and 25 per cent stained. And for this, Madras was getting Rs.5/- ($1.52) per pound, while if calculated according to Bihar prices, the average price of the bulk would be Rs.3/13/- ($1.16) per pound. In this case also, they were getting a 26 per cent higher price, though the predominance of small black and red specks, which is remarkable in such green BQ, is not tolerated even in the heavily stained quality of Bihar. Under these circumstances, it seems obvious that there was something radically wrong with the method of establishing prices, which unfortunately went very much against the interests of the Bihar mica trade.

However, one must take comfort from the thought that the war is over and the industry has survived the crucial test it was put to. A natural consequence of this "all-out" purchase of mica by the Joint Mica Mission and the sudden termination of the war left the United Kingdom government with huge surplus stocks of all categories of mica, especially loose splittings of all grades. This undesirable accumulation of stocks purchased at low prices gave rise to the question as to how it would affect the post-war Indian mica market, if this stock was suddenly unloaded on the foreign markets at the government's cost price. That such unloading would knock the bottom out of price structure altogether and paralyze the Indian mica trade completely, there could be no doubt. The anxiety of the trade was shared by the government of India, who had given an exclusive monopoly of purchase to the Joint Mica Mission without any reservation or understanding in respect to any matter whatsoever.

The government of India, therefore, ultimately sent a delegation to England led by Mr. (now Sir) H. C. Prior, the then secretary of the Labour Department, with two members of the Indian mica trade (of which the author was one), the director of the Geological Survey of India, and a representative of the government of Bihar, to discuss these matters with the department of supply in London and to arrive at an agreement ensuring a regulated and restricted sale of these surplus stocks. After fairly long discussions and conferences, an agreement was entered into (see Appendix 1).

The parties to this agreement are the government of India and the government of the United Kingdom, and it will be clear from a perusal of its terms that the object of the agreement was to enable the prices of mica in post-war years to seek and then maintain their own levels. Uneconomic prices were to be avoided by preventing such factors as the sudden impact of sale of wartime surpluses. With a view to eliminating the danger of the government's surplus stocks competing with the current production, it was expressly provided in Clause 5 that, so far as is practicable, the prices at which government stocks are sold will be kept in line with the prevailing market prices. The implication was clear that sale of government stocks should be in a manner so as to avoid serious adverse changes in prices. The meaning and purport of this clause could hardly be mistaken, but new price issues have been raised by the British mica trade, which questioned the very spirit and purpose of the agreement.

To make out that the prices asked for by the trade are uneconomic or otherwise unreasonable, a comparison cannot reasonably be made with the Joint Mica Mission prices of the war period. Whatever may be said of the Joint Mica Mission prices during the war period, they are by no means the proper price to be paid for Indian mica during the post-war period. The contrast between the conditions of 1942 and those of the post-war years is so marked that it is indeed surprising that the prices of the former years are cited as a standard for the prices of the present time. It may be asked, however, how the industry maintained itself if the Joint Mica Mission prices were so uneconomically low. The question gains in force when it is mentioned that at that time the industry not only maintained itself but was even able to make a profit.

To explain the paradox of profits with uneconomically low mica prices, one must examine more closely into the operating conditions during the war period. It may be said at the outset that such profits as were made by the producers were largely uneconomic, since they were made at the expense of the more abiding interests of the future. For example, the sale of mica obtained from stoping the existing developed mines produced a profit only in a narrow pecuniary sense. The costs of operation could not be reckoned in terms of the usual wage and other operating costs because the uneconomic practices resorted to under pressure of wartime exigencies were coupled with numerous aids provided under official auspices which in ordinary peacetime would be characterized as state subsidies. Uneconomic practices and subsidized aids together explain the paradox of profits and low prices. Such mica prices can, under no circumstances, be regarded as the standard by which to regulate the prices of mica produced under present peacetime conditions.

The aid which the industry obtained free during wartime or at less than the usual cost, which enabled the industry to sell its output at the Joint Mica Mission prices, included the supply of rice at cheap rates for the workers. This resulted in stable wage rates. The need for machinery was supplied by government or quasi-government departments. Jeeps provided for supervision work around the mines and portable compressed-air units supplied at nominal rent went a long way in saving the industry from making considerable capital investments.

Added to these facilities was the mica bonus, which was given to the industry on a sliding scale based on sales of strategic mica to the Joint Mica Mission, with a view to compensate the producers against the excess profit tax.

The effect of this bonus scheme, though not great in all cases, was very favourable in some, and on the whole it became an incentive for producers to do their utmost in increasing production. In spite of these aids it was difficult to produce all the mica required under war conditions. A fairly adequate supply could be assured only by depleting the industry's reserves in mines built through years of effort and at great cost. A labour shortage created by the construction of military road projects in the vicinity of mica fields at that time also forced mining of reserves with less man power. Added to this was a lack of proper mechanical equipment and of spare parts, which could not be made available to the industry in sufficient quantity in spite of the best efforts of the Joint Mica Mission.

Under these conditions, the industry had no alternative but to draw upon its reserves. The largest production during the war came from stoping the developed mines. There can be no doubt that, left to themselves, few producers would have taken recourse to this suicidal policy. A number of mine inspectors were appointed under the supervisory field officer, and pressure was brought to bear upon the producers to produce every pound of easily available mica. Where any producer refused to abide by the dictates of these mine inspectors, he was denied the indispensable facilities of the Stores and Purchase Section and the Joint Mica Mission.

Hence, the cost of production, which was kept low by various subsidies, was lowered further artificially by at least 50 per cent more than under ordinary conditions by the production obtained from the obviously imprudent stoping of the best reserves.

The Joint Mica Mission no longer exists and neither do all the helpful facilities that had been afforded to the mica industry during the war years. The Bihar mica industry stands today badly exhausted and with no appreciable reserve for posterity or for struggling through lean times. Therefore, most of the new production must be obtained from development of new mines.

In view of the progressive deterioration of the food situation and other factors contributing to the cost of living since the beginning of 1946, labour and supervision costs have been constantly rising. To meet the industry's requirements of stores and equipment for mining and manufacturing mica, it must turn to the black market. Mechanical efficiency has declined considerably owing to the shortage of spare parts. Added to all these is the unfortunately low working efficiency of the labour, which is attributable partly to malnutrition and partly to an agitated state of mind because of a world-wide labour commotion. Besides these factors there are many other comparatively minor ones, which do not fall within the scope of this book. The cumulative effect of all these factors has increased production costs by more than 200 per cent. The industry no longer has a buyer for its entire production at its doorstep, nor does it enjoy the benefit of cash payment. In the Joint Mica Mission days, one could plan one's production in the factories according to one's own convenience, for any item included in the Joint Mica Mission schedule could be sold. But today production has to be planned according to the conditions of demand, which is limited only to, at the best, 70 per cent of production (in terms of value). Thus, about a third of the production must be kept in stock in the shape of blocked-up capital. In view of all these economic changes, the present price increase is not only necessary and just, but a further price increase, to cover a substantial statutory wage increase through the enforcement of a minimum wages bill, as well as compulsory insurance and provident fund schemes, is inevitable.

The pre-war conditions of foreign marketing have returned practically to their original states. The London market seems to have lost its former importance. Because of the presence of various members of the United States mica trade in India, serving as technical members on the Joint Mica Mission, the United States mica market has gained a much better knowledge and background of the Indian mica market than it hitherto had.

Besides, the war has enriched the knowledge of the people in general on the subject of commercial geography. Hence, almost all countries consuming mica are now trying to establish direct connection with the Indian producers and exporters of mica. The United States, for example, has started drawing practically its entire requirements directly from India. Because of various political and economic complications and difficulties, some European and other countries, such as Germany, Italy, Japan, etc., have not yet been able to resume their normal activities. But it may reasonably be hoped that, after things come to normal, all mica-consuming countries of the world will be drawing their requirements of mica freely from India.

Recently a group of Indian politicians became very emphatic about the desirability and necessity of working out some system of centralized marketing of mica. Considerable pressure from some political quarters was brought to bear upon the government of India to practically force such a system on the Indian mica trade in general. The congenital handicap of a complete lack of domestic consumption, which at times makes India subject to undesirable foreign dictation, especially with respect to prices, may speak in favour of having such an organization. However, owing to the impracticability of standardizing the commercial qualities of mica as well as to the widely varying nature of consumers' requirements, the proposition of any form of controlled or centralized marketing has to be considered absurd.

CHAPTER 11

Uses of Mica

Uses of mica can be discussed under the following three heads:

1. Built-up mica or micanite.
2. Sheet mica (meaning natural sheet mica, popularly known as "block mica" in India. It includes condenser films as well).
3. Mica powder or ground mica.

BUILT-UP MICA OR MICANITE

By far the largest quantity of mica consumed in the electrical industry is in the form of built-up mica (Fig. 59). This is manufactured primarily of thin mica splittings, assembled into large sheets by the use of suitable adhesives. Broadly speaking, the manufacture of micanite is accomplished in three or four stages, though different concerns adopt different methods, especially with regard

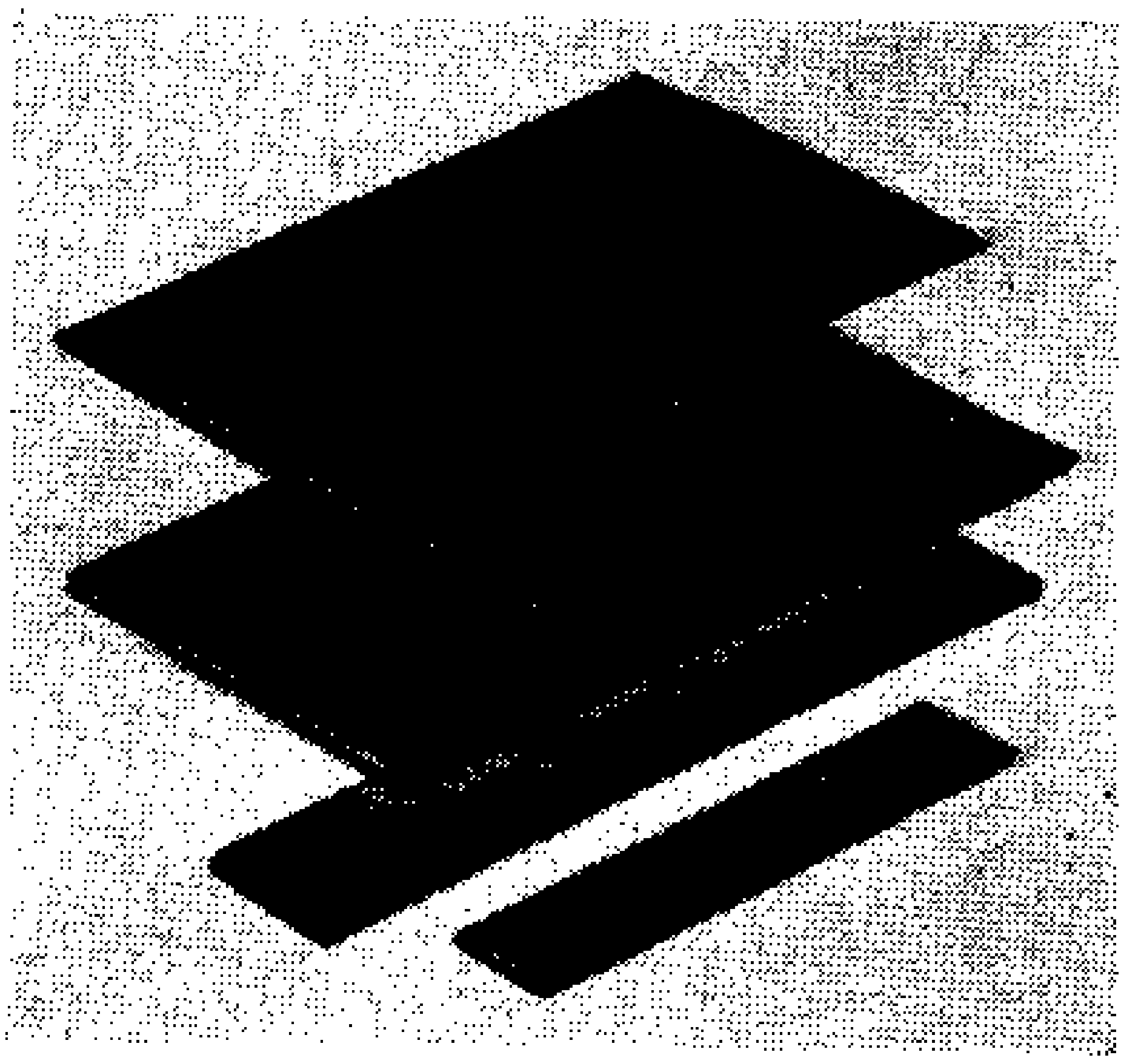

FIG. 59. Showing plates of built-up mica or micanite. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

to the first operation, which is popularly known as "laying the plates."

This first step of laying down successive layers of splittings offers considerable difficulties, for no layer thus laid should be more than 0.001, 0.002, or 0.003 in. thick, and each layer must be as nearly uniform and homogeneous as possible, without bare spots or thick spots. This perplexing problem has given birth to several procedures and types of apparatus. Though common to practically all machine-made mica board, the principle of suction in the initial laying of dry loose splittings is employed.

A brief but graphic description of some of these methods, contained in the United States Tariff Commission report, "The Mica Industry" (page 61), is quoted below to give the reader a general idea of the subject.

> Some manufacturers use an arrangement whereby these flakelike splittings are dropped from a revolving trommel having large apertures, or over a series of staggered baffle plates, to give the effect of snowfall. In some plants, near the bottom of the snowing tower, as it is called, the flakes of mica are deflected toward a sectional, perforated revolving drum from which air is continually being drawn by a suction pump. As the perforations in the revolving drum become covered or clogged by splittings that are sucked against them, there is no further deflection toward such points. The section of the aspirator that is exposed to the falling flakes of mica quickly becomes covered with at least one layer, but not more than two or three layers (that may have overlapped in falling), and as it revolves, carrying its light load of splittings down beyond the stream of falling flakes, the suction is automatically stopped on that section of the drum, and the layer of splittings drops off on to a table, where it is sprinkled with binder. Some plants use a long, moving suction screen instead of a drum; in others the snowing tower itself moves back and forth over a certain area of a long stationary table [Fig. 60]; in still others a box with a perforated bottom is lowered into a shallow pile of splittings that has been roughly leveled off, a suction is created, and the box with its layer of adhering splitting is raised and travels forward to a paper- or cloth-covered plate, upon which it deposits the splittings when the suction is released, after which the box returns for another load. All these movements are synchronized and mechanically operated. The means of applying and measuring the amount of the binder vary from plant to plant, as do the drying ovens, presses, inspection methods, and other equipment and processes which are employed.

After laying the plates on a piece of paper or a fine-mesh screen, to the desired thickness, which varies from 0.004 in. to perhaps ⅝ in. (in area usually 18 by 36 in. or 36 by 36 in.), the plates thus laid are placed in a vacuum oven (as shown in Fig. 61) having a temperature as high as 250°F. for the purpose of driving off the volatile contents of the varnish or the binding solution used.

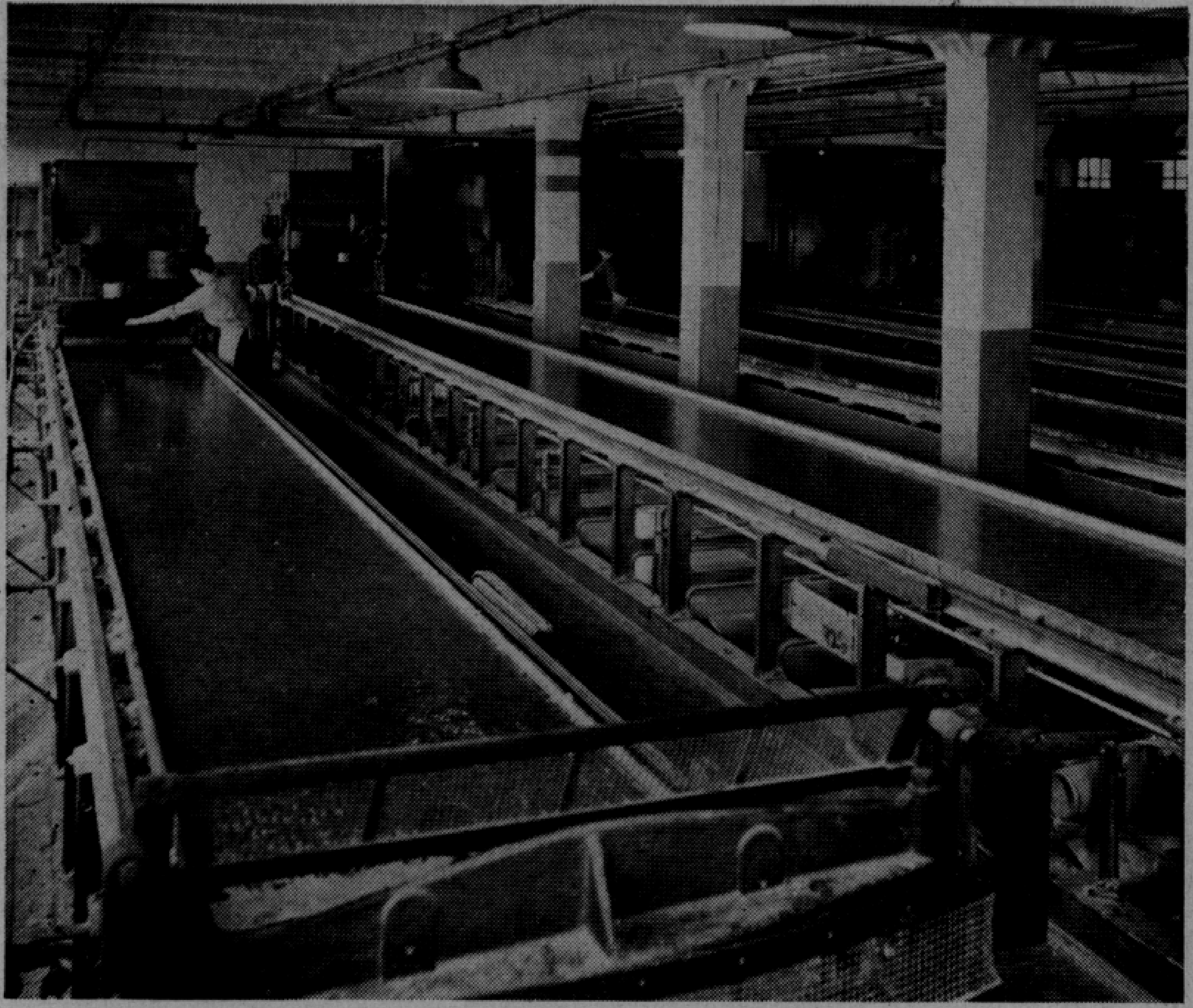

FIG. 60. Showing snowing tower moving back and forth over a long stationary table on which the plates are laid. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

After this operation, all the plates are taken to a dark room for inspection over strong light (Fig. 62) or sometimes even by means of X rays to detect imperfections such as spots bereft of binder or deficient in mica splittings (such spots being mostly repaired by hand). During this inspection, attention is also paid to the elimination (by hand) of any objectionable metallic stain that might have crept in with some splittings or any heavy ends that might hinder molding operation. After such adequate checking, the plates are then passed on to a steam-heated hydraulic press (Fig. 63), where they are subjected to a great pressure (approximately 1,000 lb. per sq. in.) at a temperature around 300°F. for several minutes. Immediately after the specified period of hot compression, cold water is circulated through the press in order to chill them quickly.

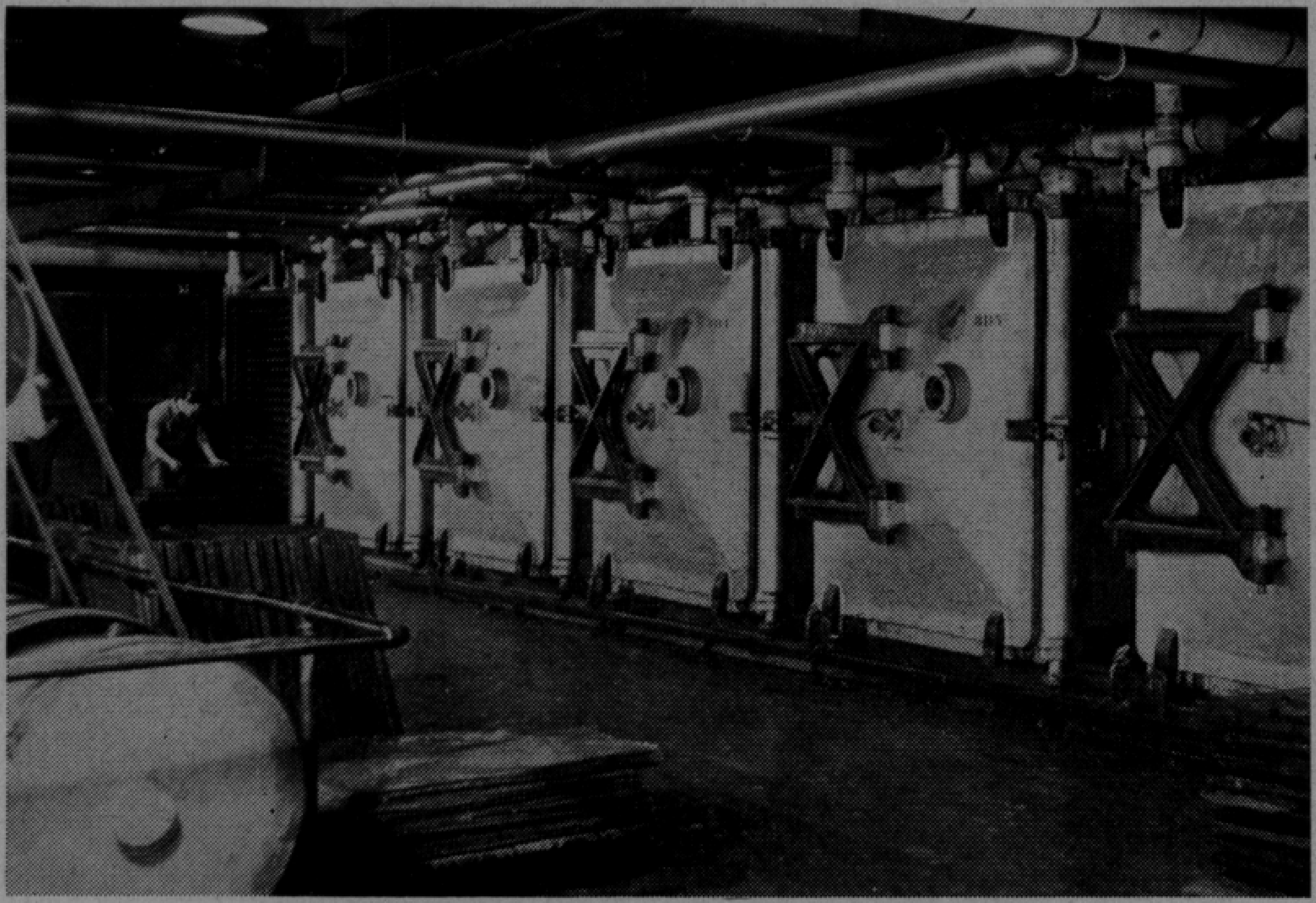

FIG. 61. Showing vacuum ovens employed for driving off the spirit contents of the varnish used for laying built-up mica plates. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

The micanite plates thus built up are then ground to required thickness and to flat surface by carborundum rolls, and finally the sides are trimmed by saw blades or shearing machines to the desired dimensions.

According to information available from the cyclostyled "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by the Associated Insulation Products, Ltd., London, it appears that, though some of the methods already described are followed in England, some other different methods are also employed in the manufacture of micanite. The most important of them are (1) hand building and (2) tower building. These two methods differ from each other, in respect to both "laying the plates" and "applying the binder or varnish."

Hand Building. An overlapping layer of mica splittings is spread out on a flat surface with or without an intervening thin sheet of paper, no space being left uncovered by the splittings. This layer is brushed over or sprayed with an insulating binder such as shellac or other suitable varnish, and whilst the binder is still wet another layer of splittings is deposited on the first layer, in such a manner that the joints of the splittings of the first are covered by whole splittings of the second layer. This process continues until the height needed to produce the desired final thickness of micanite product is reached. The plates thus laid are then passed on to a steam-heated hydraulic press and are subjected to high pressure

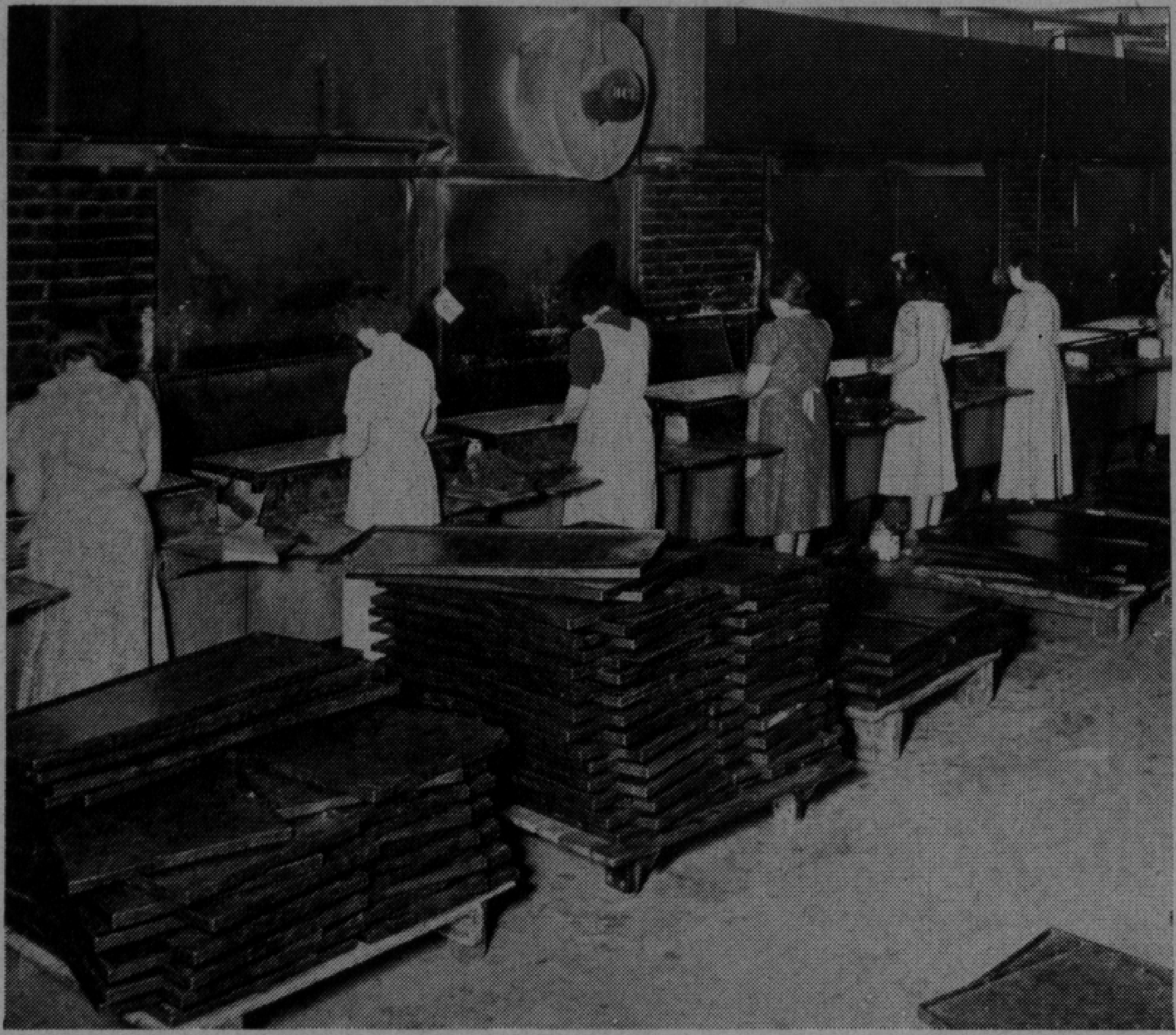

Fig. 62. Showing inspection of built-up mica plates prior to their subjection to hot compression. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

for a specified period, depending on the purpose for which the micanite is intended. This operation serves the double purpose of driving off the volatile solvents of the varnish used as binder, as well as compressing the plates. This method of manufacture is said to be usually adopted when a micanite product having high electrical breakdown value is desired.

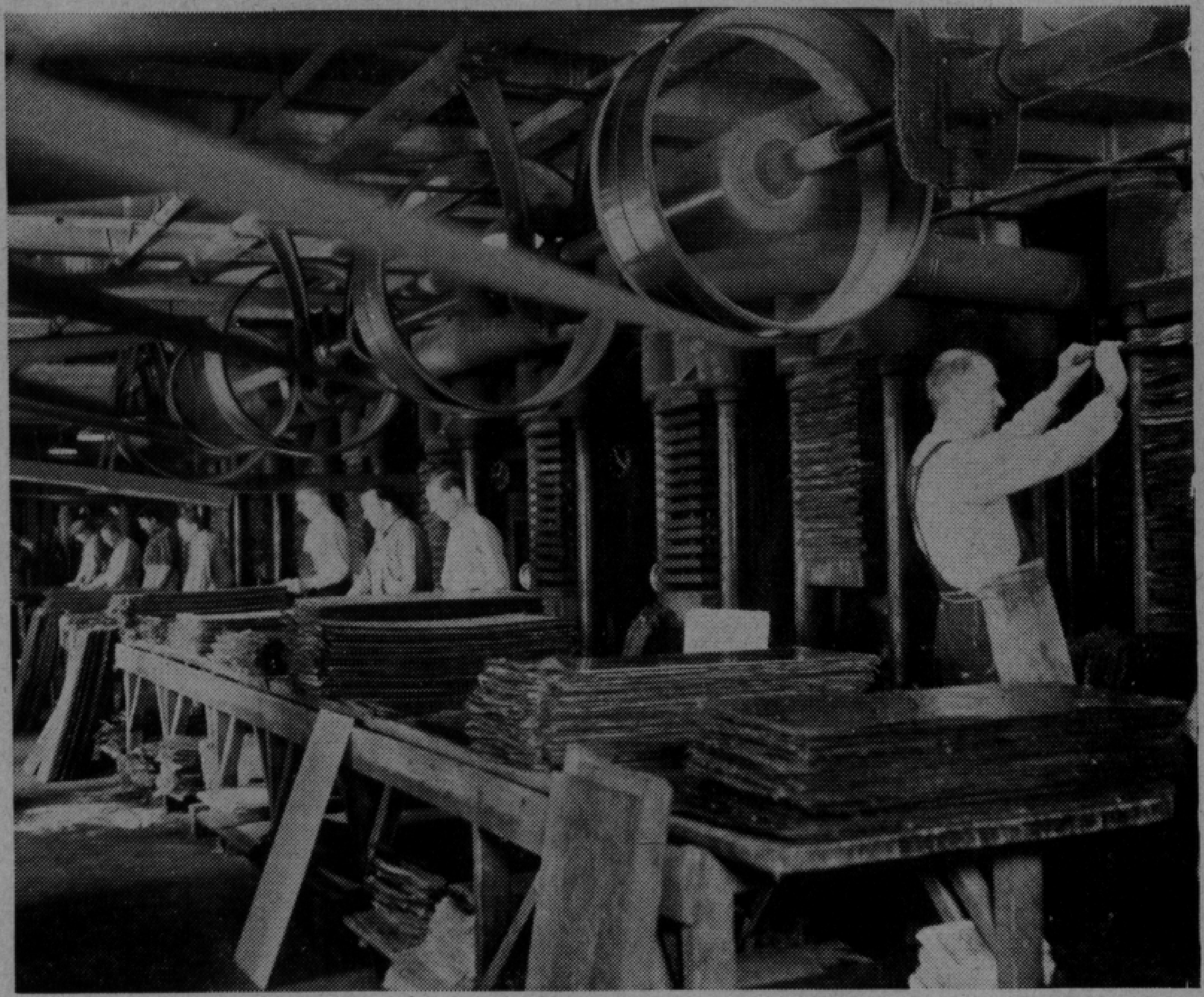

FIG. 63. Showing hydraulic press employed for the hot compression of the built-up mica plates. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

Tower Building. This method employs a tall tower, popularly known as a "snowing tower." The loose splittings are allowed to fall from the top of this tower in such a manner as to produce the effect of snowfall, together with a dry, powdered adhesive agent. By careful design, both the splittings and the powdered bond can be evenly distributed on a collecting plate or tray at the bottom of the tower.

After sufficient mixture of such "snowed" splittings and the

TABLE 16

PRODUCTION OF TYPES OF BUILT-UP MICA IN UNITED STATES *

Product and type of mica used	*Quantity, lb.*	*Value*	*Value per lb.*†
Molding plate:			
Muscovite	817,995	$ 703,688	$0.86
Phlogopite			
Segment plate:			
Muscovite	541,784	528,652	0.98
Phlogopite	242,086	406,002	1.68
Heater plate:			
Muscovite	159,123	184,916	1.16
Phlogopite	35,048	66,586	1.90
Flexible (cold):			
Muscovite	176,345	183,026	1.04
Phlogopite			
All other (tape), etc.:			
Muscovite	375,470	790,685	2.11
Phlogopite	37,772	84,987	2.25
Total built-up mica	2,385,623	$2,948,545	1.24
Total splittings used (all imported)	2,659,318	$ 607,657 ‡	0.225

* Source: United States Tariff Commission report, "The Mica Industry" (1935 production).

† Values for one company estimated by using average unit values of all others.

‡ Duty paid f.o.b. domestic factory.

bond has been deposited on the collecting plate to give the resultant micanite plate of the desired thickness, the plate thus laid is removed from the bottom of the tower to an oven, where the binder is melted. Finally after the melting of the binder, the plate is subjected to hot pressing in a steam-heated hydraulic press, to form the final micanite sheet.

As recorded in the United States Tariff Commission report, "The Mica Industry" (page 64),

> It requires about 115 pounds of splittings to make 100 pounds of built-up mica (average of all types). This is because of the very considerable loss in trimming the molded plates to straight edges and uniform sizes, and a certain spoilage and wastage of the splittings which are not easy to handle. The total loss in weight is generally about equal to that of the amount of binder added.

Table 16 shows the production of various types of built-up mica in the United States in 1935. A perusal of this table shows that the cost of mica (duty paid) represents only about 20 per cent of the total value of the finished product, *i.e.,* built-up mica.

Micanite or built-up mica sheets are made in various types, to suit different purposes, such as hard boards, sheets for punching out shaped pieces or for molding purposes, or in flexible forms, etc. These various types of built-up mica have distinct uses and differ chiefly in the proportion and the kind of bonding material employed. The expression "micanite" is widely used as a generic term to signify built-up mica insulation of this nature.

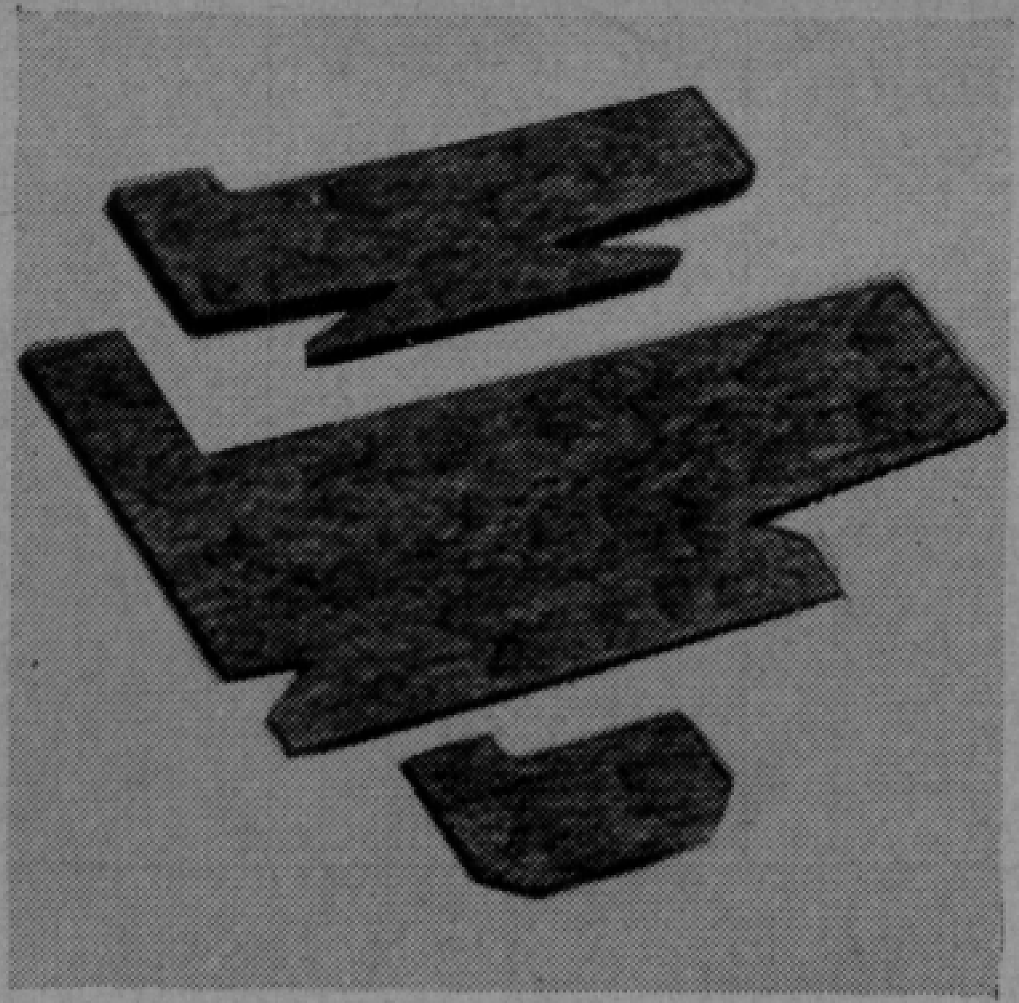

FIG. 64. Commutator segments punched from built-up mica. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

An exhaustive survey of all the types does not, however, fall within the scope of this book. Hence, only a few popular types are being described below, with tables showing popular stock thicknesses, weight per sheet of standard size, and list prices per pound (current in 1942). A perusal of the tables will reveal how the unit price of built-up mica generally increases with the decrease in thickness.

TABLE 17

POPULAR STOCK THICKNESS AND PRICES COMMON FOR MILLED SEGMENT PLATE, 1942 *

Thickness, in.	*Pounds per sheet of* 18 × 36 *in. approximately*	*List price per lb.* (1942)
0.015	0.90	$3.00
0.020	1.20	2.65
0.025	1.50	2.45
0.030	1.80	2.20
1/32	1.90	2.20
0.035	2.10	2.20
0.040	2.40	1.90
0.045	2.70	1.90
3/64	2.85	1.90
0.050	3.00	1.90
1/16	3.80	1.90

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

Commutator Micanite. This is generally made of No. 6 loose splittings of comparatively lower grades such as third-quality or second-quality loose splittings, depending on the thickness of the plate (see Fig. 64).

Hard-board Micanite. The principal constituents of this type are practically the same as those of commutator micanite, though it contains a rather higher adhesive content. This type of micanite is used as baffle boards and insulation barriers, and for punching washers and flat insulation pieces, as shown in Fig. 65.

TABLE 18

HARD-BOARD MICANITE *

Thickness, in.	*Pounds per sheet of* 18 × 36 *in. approximately*	*List price per lb.* (1942)
0.010	0.567	$2.70
0.015	0.850	2.60
0.020	1.200	2.40
0.025	1.500	2.20
0.030	1.800	2.00
1/32	1.900	2.00
3/64	2.85	1.70
1/16	3.80	1.50

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

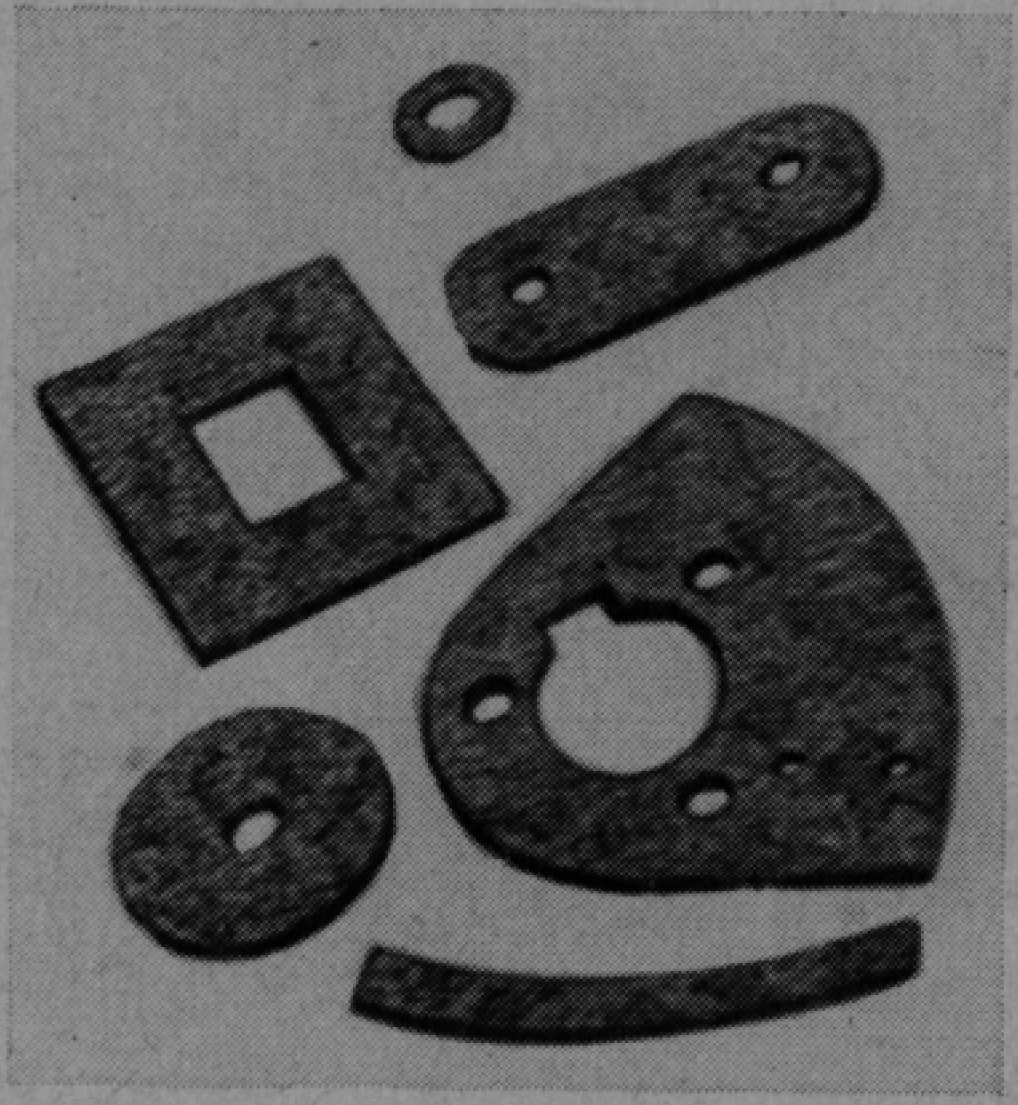

FIG. 65. Flat insulation pieces punched from hard-board micanite. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

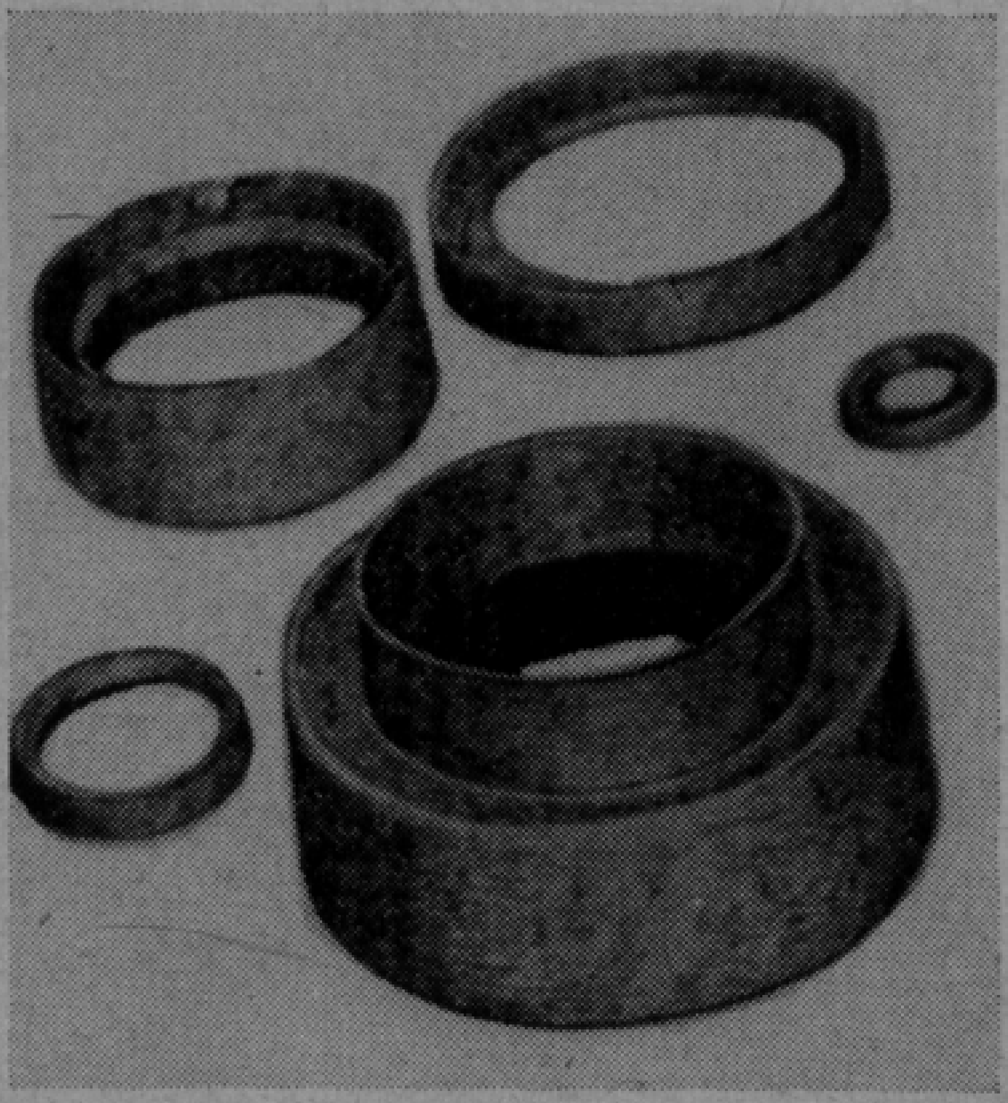

FIG. 66. Showing V rings, troughs, etc., molded from molding micanite. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

Molding Micanite. Prepared from the same material as above, it has 13 to 15 per cent adhesive contents (usually shellac). When subjected to a heat of about 275°F. it becomes flexible and can readily be molded into shape without breaking or flaking. It is suitably used for molding commutator V rings, troughs, liners, and tubes (as shown in Fig. 66).

TABLE 19

MOLDING MICANITE *

Thickness, in.	*Pounds per sheet of* 18 × 36 *in. approximately*	*List price per lb.* (1942)
0.015	0.80	$3.50
0.020	1.05	3.00
0.025	1.30	2.55
0.030	1.60	2.10
1/32	1.70	2.10
0.035	1.85	2.10
0.040	2.10	1.95
0.045	2.35	1.95
3/64	2.50	1.95
0.050	2.65	1.95
1/16	3.30	1.70
3/32	5.00	1.70
1/8	6.50	1.70

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

Cold-forming or Flexible Micanite. This is usually manufactured from comparatively higher grades of mica splittings, such as No. 6 second-quality loose splittings for plates above 0.02 in. thick, No. 6 first-quality loose splittings for plates between 0.01 to 0.02 in. thick, and 5½ loose splittings or better for thinner plates, with or without paper reinforcement.

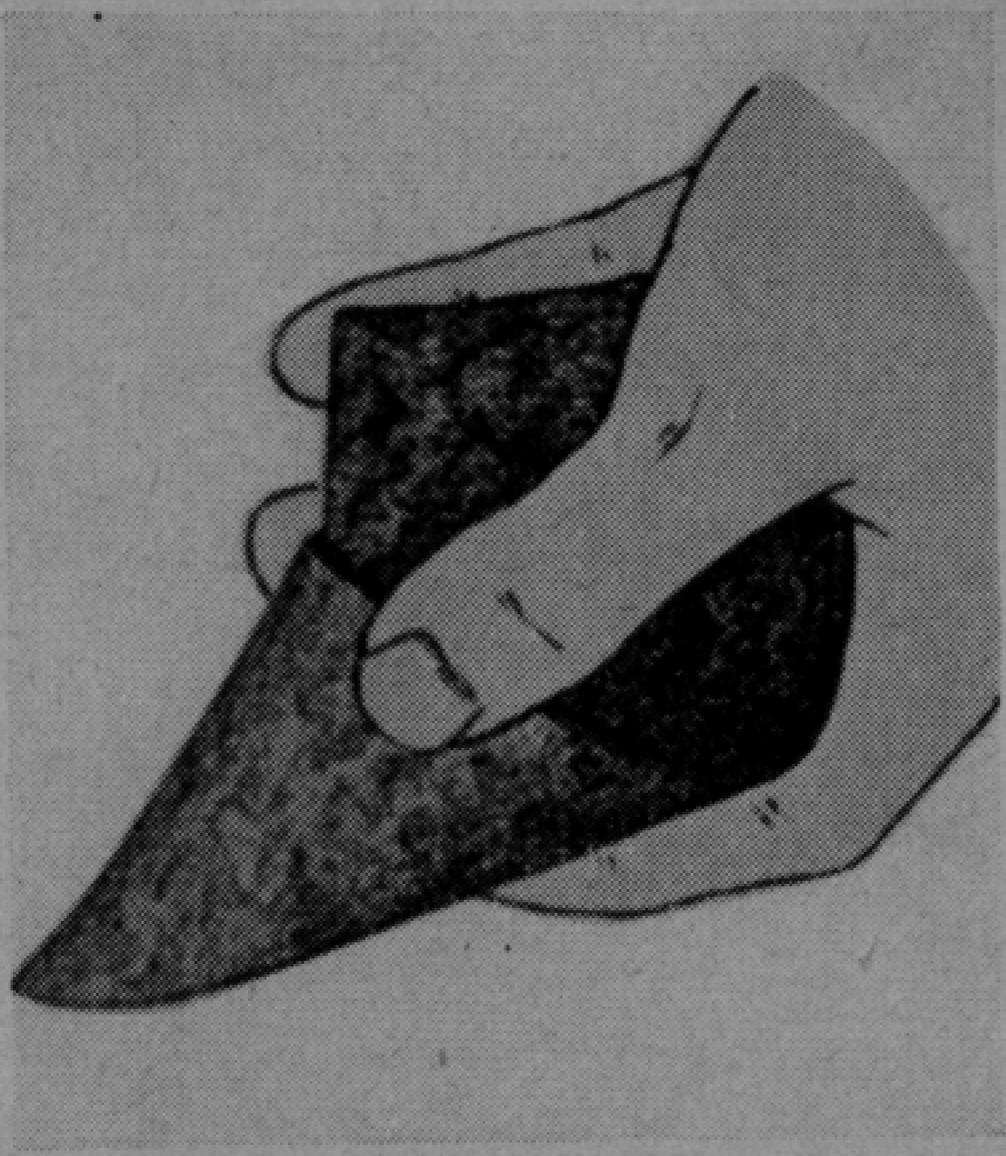

FIG. 67. Showing cold-forming micanite. The photograph illustrates its flexible character when cold. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

The binder consists of a special mixture of resins and gums with certain oil, usually including a preparation of nondrying oil, for example, castor oil. In the manufacture of this particular type of flexible micanite, the proportion of the bonding material used is higher than that in the regular molding plate, approximately 16 to 20 per cent. As the name signifies, it can be formed and bent to any shape without the application of heat, as shown in Fig. 67.

It is considered excellent in insulating armature slots, transformers, magnets and commutator cores, and field coils. Such plates usually stand a high puncture test.

TABLE 20

COLD-FORMING OR FLEXIBLE MICANITE *

Thickness, in.	*Pounds per sheet of* 36 × 36 *in. approximately*	*List price per lb.* (1942)
0.005	0.55	$3.15
0.010	1.00	2.00
0.015	1.45	1.75
0.020	1.90	1.75
0.025	2.30	1.60
1/32	3.00	1.60
1/16	6.00	1.55
1/8	12.00	1.55

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

Heater Plates or Heat-resisting Micanite. This form of micanite is generally made either from muscovite or phlogopite splittings, the latter being preferred for application where temperatures around 1500°F. have to be encountered, though muscovite also is supposed to withstand a temperature of 1250°F. Muscovite heater plate is usually manufactured from No. 6 first-quality loose splittings or better, with a very small amount of binder, say about 1.5 per cent by weight (not exceeding 4 per cent in any case). The binders used are certain inorganic materials, such as silicate of soda, and kaolin, though the exact composition of such binders being a trade secret, it is not always disclosed by manufacturers. The material lends itself to uses in all cases where high insulation strength under high temperature is required, for example, kettles, irons, heaters, toasters, in furnace work, etc. Hence it is used for punching various types of heat-resisting plates as shown in Fig. 68.

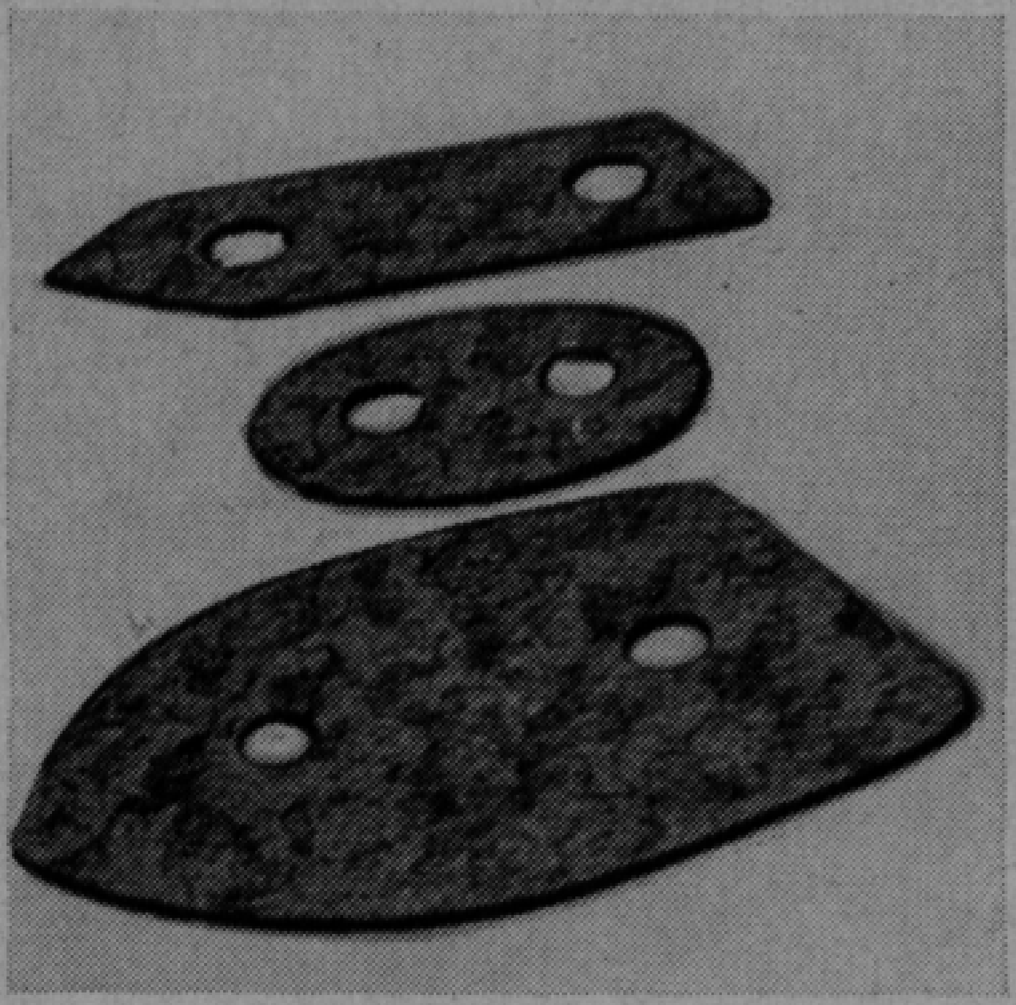

Fig. 68. Showing patterns punched out of built-up mica of the heat-resisting type. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

TABLE 21

Amber Heater Plate *

Thickness, in.	*Pounds per sheet of* 18 × 36 *in. approximately*	*List price per lb.* (1942)
0.010	0.60	$4.75
0.015	0.85	4.65

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

Flexible Micanite. Now we pass on to a short description of some popular types of thin flexible micanite, manufactured in the shape of thin mica cloth, mica paper, sheets, ribbons, tapes, etc. In the manufacture of this particular variety, usually the mica splittings are not laid down by suction or machine, as in the case of other types of micanite discussed previously. The layers of splittings, seldom over three or four, are placed carefully by hand on a sheet of varnished cloth, silk paper, etc. Hence the type of splittings generally used are book-packed splittings of all grades from No. 6 to No. 4 or even higher grade loose splittings (from No. 6 first-quality to No. 4).

The adhesive material is usually applied by a hand brush, first to the silk cloth or paper on which the splittings are laid, and then to the successive layers of mica, and amounts to between 15 to 20 per cent of the total weight of the finished product. This type of built-up mica is first produced in rolls about 36 in. wide, and even up to a length of 100 ft. If and when required, these are cut into strips from ½ to 1 in. wide. These sheets or ribbons of built-up mica are made in thickness from 0.004 to 0.0015 in. including the paper or cloth of silk facing one side or on both sides. The uses for this type of thin sheet or ribbon material are many, principally in winding for insulating all sorts of electrical parts.

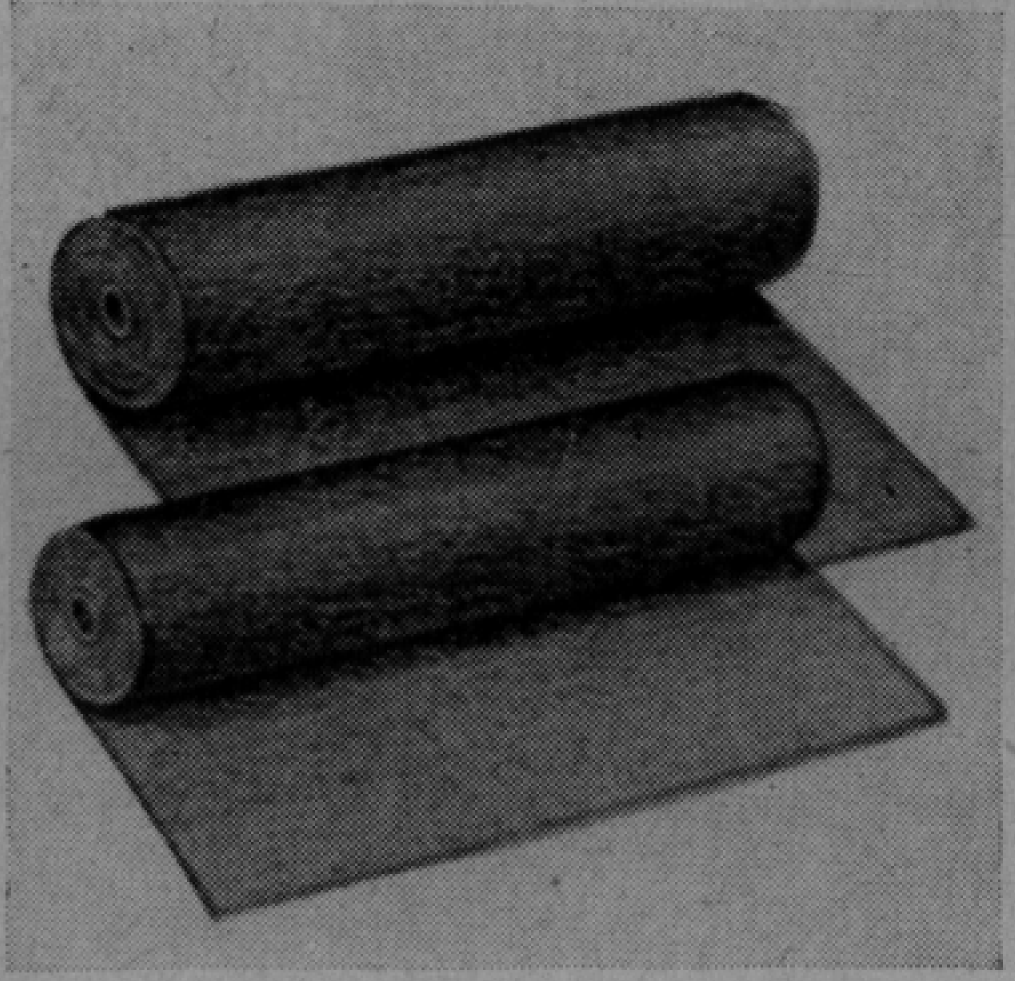

Fig. 69. Showing a roll of mica paper. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

Mica Paper (Fig. 69). This form of flexible micanite is made of one, two, or three layers of carefully selected usually No. 5½ or larger muscovite book-packed splittings, or even loose-packed splittings of the larger grades, bound between layers of Japanese rice paper, in sandwich form. A minimum of binder is used in its preparation.

It is generally used in armature slots, commutator cores, special wraps, and coil insulation in electrical machines and extra high-

TABLE 22

MICA PAPER *

Thickness, in.	*Layers of mica*	*Pounds per sheet of* 18 × 36 *in. approximately*	*List price per lb.* (1942)
0.005	1	2.40	\$3.50
0.008	2	4.00	3.00
0.011	3	5.30	2.50

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

tension transformers. This can be used also as magnet-core and field-coil insulation. The double-paper reinforcement helps to prevent disintegration in handling and application.

Mica Cloth (Fig. 70). This again is a special form of flexible micanite, employing slightly lower grade splittings than those employed in mica paper, *e.g.,* No. 6 first-quality loose splittings for sheets over 0.016 in. thick and 5½ loose or book-packed splittings for thickness between 0.01 to 0.016 in. or higher grades for thinner sheets. Practically the same binders are used, but instead of with paper, it is reinforced with fine-quality linen cloth or muslin on both sides, or on one side only, with paper on the other side. Its uses are practically the same as those of mica paper, but mainly for cases where the extra mechanical strength of the reinforcement is desirable.

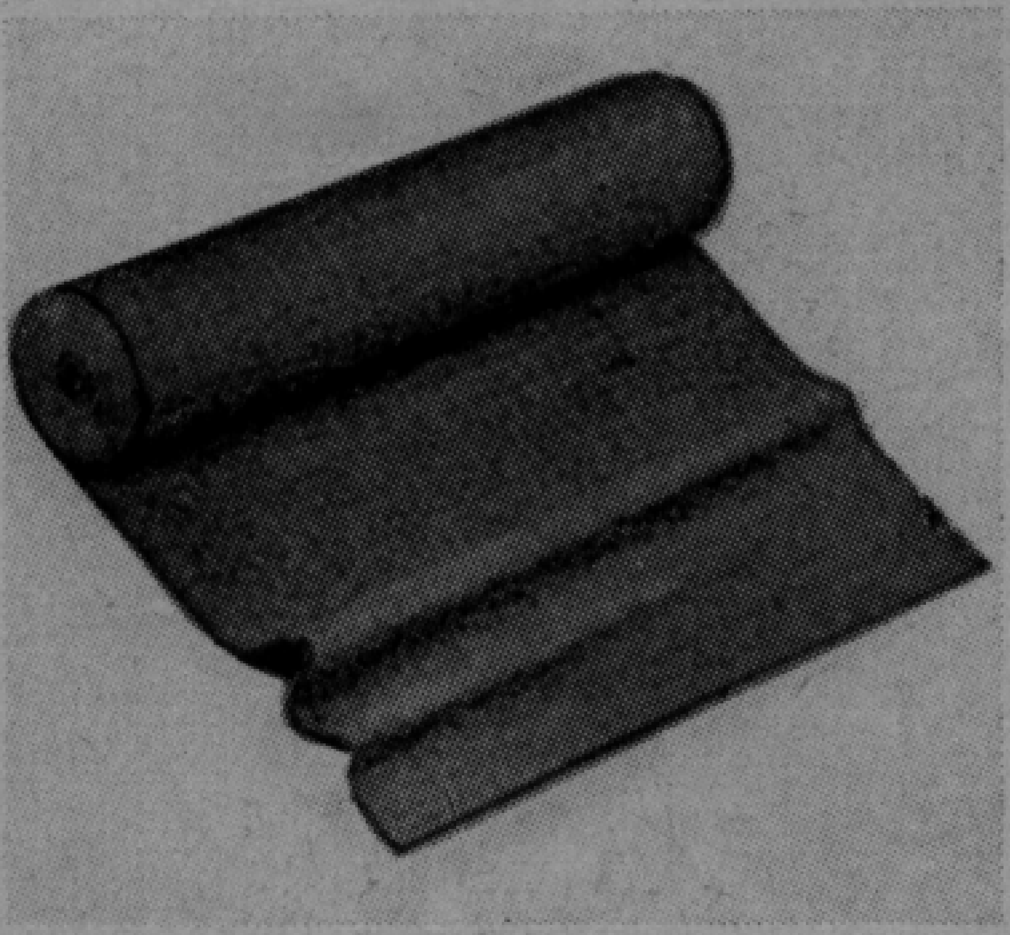

FIG. No. 70. Showing a roll of mica cloth. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

TABLE 23

MICA CLOTH *

Thickness, in.	*Layers of mica*	*Pounds per sheet of* 16 × 32 *in. approximately*	*List price per lb.* (1942)
0.008	1	3.00	$3.50
0.011	2	4.50	3.00
0.014	3	6.00	2.40

* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

Mica Silk. In this particular type of flexible micanite splittings of up to grade 4 (generally book-packed splittings) are bound to fine Japanese silk. It is generally supplied in tape form to facilitate wrapping on bars and electrical winding.

Mica Tapes. Mica tape is manufactured practically in the same manner as mica cloth or mica silk. But in addition to rice paper, silk, and cloth, cellophane or glass is also used as top and bottom coverings. Initially these are manufactured in large sheets of about 120 by 36 in., and then tapes of various widths ranging between ½ to 1 in. are cut out of the rolls of these large sheets. Generally these tapes are manufactured in thicknesses between 0.005 and 0.007 in., though they can be manufactured to any specified thickness that may be desired by a

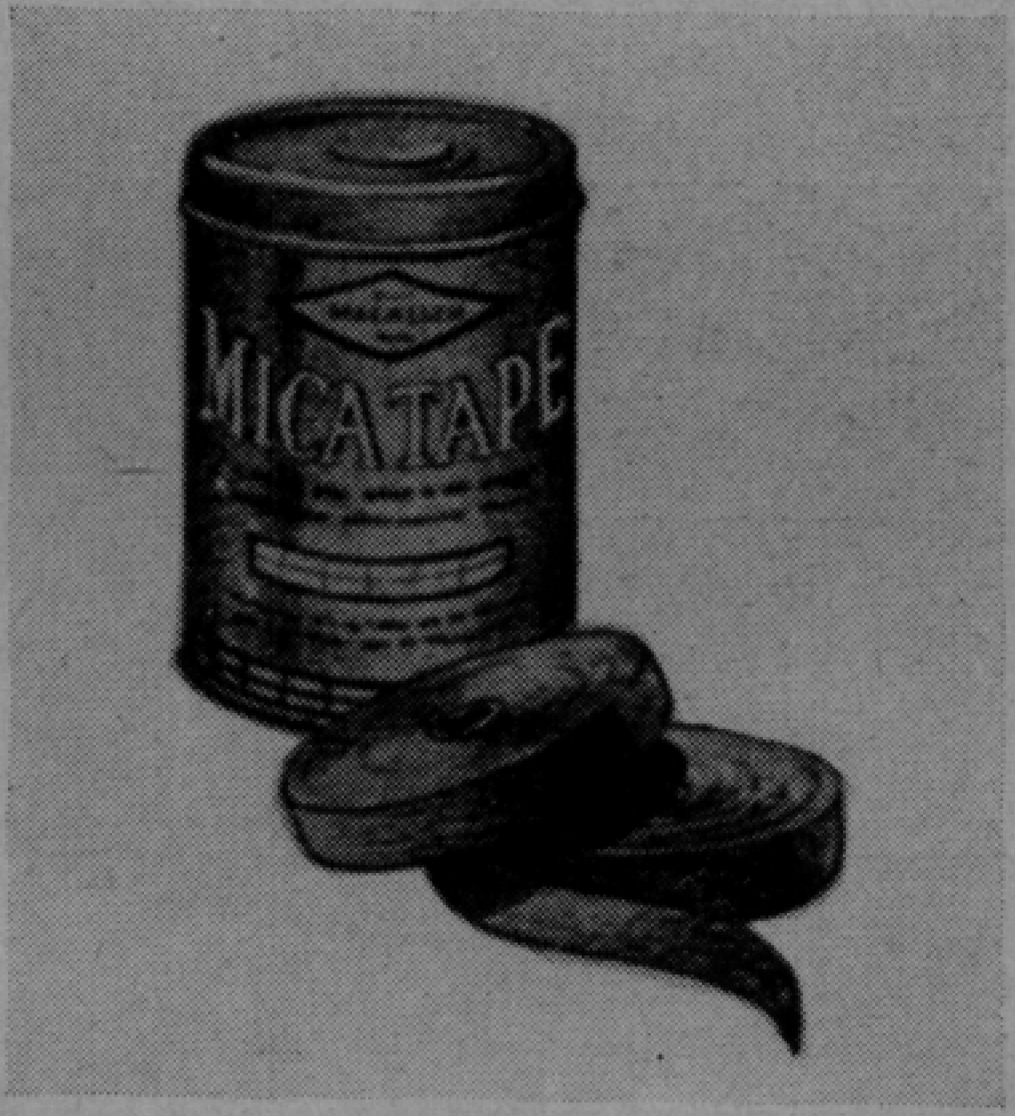

FIG. 71. Showing a roll of mica tape and a can in which it is packed. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

TABLE 24

MICA TAPES *

Type	*Width, in.*	*Diameter of rolls, in.*	*Feet per roll*	*Weight per roll*	*List price per lb.*
0.003 silk	½	3¾	150	0.18	$6.00
0.001 silk one side	⅝	3¾	150	0.23	6.00
Nothing other side	¾	3¾	150	0.28	6.00
	1	3¾	150	0.37	6.00
0.005 silk	½	3⅞	150	0.27	3.75
0.001 silk one side	⅝	3⅞	150	0.34	3.75
0.001 paper other side	¾	3⅞	150	0.38	3.75
	1	3⅞	150	0.54	3.75
0.005 silk	½	3½	100	0.14	3.75
0.001 silk both sides	⅝	3½	100	0.18	3.75
	¾	3½	100	0.22	3.75
	1	3½	100	0.29	3.75
0.007 fabric	½	5	150	0.30	3.75
0.002 fabric one side	⅝	5	150	0.37	3.75
0.001 paper other side	¾	5	150	0.45	3.75
	1	5	150	0.59	3.75
0.005 cellophane	½	4	190	0.33	3.75
0.001 cellophane both sides	⅝	4	190	0.42	3.75
	¾	4	190	0.50	3.75
	1	4	190	0.67	3.75
0.005 paper	½	3⅞	150	0.30	3.75
0.001 paper both sides	⅝	3⅞	150	0.37	3.75
	¾	3⅞	150	0.45	3.75
	1	3⅞	150	0.59	3.75
0.005 glass	½	4	150	0.26	6.00
0.002 glass one side	⅝	4	150	0.33	6.00
0.001 paper other side	¾	4	150	0.39	6.00
	1	4	150	0.52	6.00
0.008 glass	½	4⅛	108	0.26	6.00
0.003 glass one side	⅝	4⅛	108	0.32	6.00
0.001 paper other side	¾	4⅛	108	0.38	6.00
	1	4⅛	108	0.51	6.00

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* Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.

particular consumer. Hence these warrant the use of the highest grades of mica splittings, mostly such as No. 5 or No. 4 book-packed splittings. As shown in Fig. 71, they are furnished in rolls, which are packed in cans. A study of Table 24 will acquaint the reader with the various popular specifications and the prices in the United States during 1942.

Mica Tubing. Compressed sheet mica tubing is manufactured from molding micanite in various shapes, such as square, oval, hexagonal, octagonal, or any other shape that may be desired by a consumer. Besides, these are manufactured in over 2,000 sizes ranging from ⅛ to 4 in. inside diameter and 1/64 to ¼ in. wall thickness. As described below, such tubing may be made of 100 per cent mica or partly mica and partly paper or asbestos. These have to be manufactured accurately to specified dimensions. Generally such tubings are compressed so hard that on being struck they produce a metallic sound and are claimed to possess great tensile strength and electrical resistance. The popular varieties are as follows:

1. All-mica Tubing. This is made of molding micanite plate and represents the higher grade of tubing. It possesses high electrical resistance and does not soften easily. Hence, it is recommended for high potential work where sufficient heat is to be encountered to render paper untenable. It is generally used for sleeves for small commutators, brush-stud holders, grid-rheostat rods, etc.

2. 98 per cent Mica Tubing. This is exactly the same as the all-mica tubing, except that a thin covering of paper is applied on the outside of the tube to guard against scaling and opening up when assembled. This protection is often desired where it is possible to use a paper covering.

3. 85 per cent Mica Tubing. This tubing is offered where a high-grade insulation is desired and where a small amount of paper can be used with the compressed sheet mica. A small amount of paper, about 15 per cent, does not materially affect the insulating qualities and does lower the cost.

4. Asbestos and Mica Tubing. This tubing is composed of about 40 per cent compressed sheet mica and 60 per cent asbestos. It is

TABLE 25

Standard Composition, Tolerance, and Properties of Manufactured Sheets and Wrappers *

N.E.M.A. No.	*Type of material*	*Bond content, %*	*Splittings, N.E.M.A. grade*	*Nominal thickness, in.*	*Variations in average † thickness of individual plates and rolls from the specified nominal thickness, in.*		*Variation in individual measurements from the nominal thickness in any one plate or roll, in.*	
					Plus	Minus	Plus	Minus
1	Molding plate milled.........	Not over 16	F	0.015 and over	0.002	0.002	0.003	0.003
2	Molding plate, unmilled......	Not over 16	E	Up to 0.015	0.003	0.003	0.005	0.005
			F	0.015 up to 0.062	0.005	0.005	0.008	0.008
			F	0.062 and over	0.007	0.007	0.010	0.010
3	Segment plate (muscovite), milled...................	Not over 6	F	0.015 and over	0.001	0.001	0.002	0.002
4	Segment plate (phlogopite), milled...................	Not over 6	P or better	0.015 and over	0.001	0.001	0.002	0.002
5	Flat work plate, unmilled.....	Not over 6	F	Up to 0.062	0.007	0.007	0.010	0.010
		Not over 16	F	0.062 and over	0.010	0.010	0.013	0.013
6	Cold flexible mica, sheet......	Not over 20	C	Up to 0.010	0.002	0.002	0.003	0.003
		Not over 20	D	0.010 up to 0.020	0.003	0.003	0.005	0.005
		Not over 20	E	0.020 and over	0.005	0.005	0.008	0.008
7	Heater plate (muscovite), organic bond...............	Not over 4	D	All catalogued sizes	0.003	0.003	0.005	0.005
8	Heater plate (phlogopite), organic bond	Not over 4	Q or better	All catalogued sizes	0.003	0.003	0.005	0.005

10	Heater plate (phlogopite), inorganic bond	determinable by standard bond test	O or better	All catalogued sizes	0.003	0.003	0.005	0.005
11	Mica paper		B	Up to 0.008	0.002	0.002	0.003	0.003
			C	0.008 and over	0.003	0.003	0.005	0.005
12	Mica tape		A	Up to 0.006	0.001	0.001	0.002	0.002
			B	0.006 up to 0.010	0.002	0.002	0.003	0.003
			B	0.010 and over	0.003	0.004	0.005	0.005
13	Mica fish paper or equivalent		C	All catalogued sizes	0.003	0.003	0.005	0.005
14	Mica rope paper or equivalent		C	All catalogued sizes	0.003	0.003	0.005	0.005
15	Mica press board		C	All catalogued sizes	0.003	0.003	0.005	0.005
16	Mica cloth		C	Up to 0.010	0.002	0.002	0.003	0.003
			C	0.010 up to 0.016	0.003	0.003	0.005	0.005
			D	0.015 and over	0.005	0.005	0.008	0.008

N.E.M.A. Grade Specifications

A	No. 5 first-quality book form, pan packed, loose with powder, loose	All clean muscovite mica splittings
B	No. 5½ first-quality book form, pan packed, loose with powder, loose	
C	No. 5½ second-quality loose with powder, loose	
D	No. 6 first-quality loose with powder, loose	
E	No. 6 second-quality loose	
F	No. 6 third-quality loose	
O	No. 6 first-quality loose with powder, loose	Phlogopite (amber) mica splittings
P	No. 6 second-quality loose	

* The table has been taken from Publication No. 39–55, March, 1939, of the National Electrical Manufacturers Association, 155 East 44th Street, New York.

† Average tolerances to be based upon 10 individual measurements per sheet or per roll.

intended for apparatus subjected to moderate heat, where a cheaper priced tubing than the all-mica tubing is desired. It can be used satisfactorily on grid rheostats, resistance boxes, etc.

5. 50 per cent Mica Tubing. This tubing is composed of 50 per cent paper and 50 per cent compressed sheet mica and is designed for apparatus where there is not sufficient heat to affect the paper and where the insulating requirements can be fully met by a tube of this kind.

Though a description of the categories of splittings employed for the manufacture of different types of micanite has been provided for in the preceding pages, information in respect to this particular subject available in various reference books shows appreciable variations regarding the use of different types of mica splittings by different manufacturers in different countries.

A study of "Notes on Mica, Its Property and Its Uses in the Electrical Industry," circulated by the Associated Insulation Products, Ltd., London, reveals that in England comparatively higher grades of mica splittings than those described above in different paragraphs are used for the manufacture of various types of built-up mica.

For instance, for commutator and hard-board molding micanite, it is stated in these "Notes" that mica splittings of grades 5½ and 6 are generally used in England, whereas according to National Electrical Manufacturers Association (N.E.M.A.) Specifications, (Publication No. 2, March, 1939) only lower grades No. 6 splittings are employed for this purpose in the United States. On the other hand, most European manufacturers use even higher grades of mica splittings than those used by English manufacturers for the same purpose.

Again, the use of No. 5 muscovite splittings seems to be general in the manufacture of flexible or cold-forming micanite according to the former, while the latter uses anything between No. 6 second-quality loose splittings and No. 5½ second-quality loose with powder, depending on the thinness of the plate.

However, an examination of Table 25 will give an idea of the standard composition, tolerance, and properties of manufactured (built-up) mica sheets and wrappers of the N.E.M.A. (New York).

Bonding Materials. Preparation of the various bonding varnishes used by different manufacturers is strictly a trade secret. Hence no detailed information in respect to their exact compositions is available. But the United States Tariff Commission report, "The Mica Industry" (page 61), furnishes some information regarding the various materials used for this object, which is quoted below in full.

> The bonding agents most frequently used are (1) a shellac varnish and (2) a phthalic anhydride and glycerine compound (an alkyd resin) dissolved in alcohol. Mica plates bonded with an alkyd resin are claimed to possess a higher dielectric strength, greater resistance, transverse strength, and translucency, and that it allows of no slippage of mica splittings among themselves. It is also claimed that such an alkyd resin is less subject to carbonizing than shellac, and that products of its decomposition are non-conductors of electric current.
>
> Heater plate, used to support red hot resistance coils like those found in toasters, is bounded with certain inorganic materials, and successfully withstands temperatures of 1250°F, when muscovite mica is used and to 1500°F when made of phlogopite.
>
> There are other varnishes used for pasting mica that contain neither shellac nor alkyd resins, such as certain copals, East Indian manila, and New Zealand Kauri, dissolved in oils. Glimalac and sticolene are English varnishes used as mica-boards bonds.

USES OF BUILT-UP MICA

Built-up mica can be used in lieu of natural mica in all devices, except those calling for transparency, extreme thinness, and flexibility, very high dielectric strength, low power factor, and capability of withstanding very high temperatures.

The assembly of mica splittings to form sheets of built-up mica as already explained is effected only through processes. Hence the physical structure or the chemical composition of each individual film thus employed in the formation of micanite remains unchanged. Consequently, though mica is divested of some of its *attributes* through its transformation into built-up form, it retains essential properties, such as ample electrical resistance, dielectric strength, and ability to withstand great pressure without change in volume, as well as continuous vibration without cracking. It also withstands great heat (up to a well-defined limit), which is likely to be encountered either in the manufacture or in the subsequent operation, of electrical units or parts of such units (such as commutators) without carbonizing, "tracking" (a certain kind of charring), or deteriorating or even impairing its insulating properties in any way.

Retention in sufficient degree of the physical properties described above, coupled with its availability in any desired size, thickness, or form, *viz.,* flexible or hard, enables it to answer most demands of the electrical industries, consequently making its use indispensable in most electrical machines. The factor of cost advocates the use of built-up mica, wherever it can be suitably employed, in lieu of sheet mica. Unlike the latter, the unit price of built-up mica of a particular type does not increase progressively with the increase in its area. Large or small, the value of a piece of built-up mica of a particular type is determined solely by its total weight. Besides, the availability of sheet mica in any desired size beyond a certain limit (the maximum being lower than what is called for by some particular appliance) may safely be regarded as an absurdity for all practical purposes and ends.

Hence the uses of built-up mica generally are more exhaustive than those of sheet mica. One can without exaggeration say that the backbone of the modern Indian mica industry is the result of the invention of micanite, and its contribution to the growth of the electrical industry has been of greatest importance. A short and graphic description of its uses in some important electrical machines follows herewith.

Commutator Segments. Micanite finds its most extensive use as insulator between the copper commutator segments (Fig. 72) of all types of direct-current and universal motors and generators and of the large alternating-current motors used on electric railway locomotives. Hundreds of millions of these mica-segment insulating pieces are used annually in small motors and generators used in automobiles or trucks (each such unit using about 25 to 30 mica segments). These segments are stamped out from plates of built-up mica 0.02 or 0.035 in. thick, measuring approximately 1 in. in length by ⅜ in. in depth. Heavy-duty industrial motors and generators require much larger segments, 10 or 12 in. long or even more, and some extra heavy-duty generators and motors operating at high voltage require much larger segments than any of those mentioned above.

> The number of segment plates needed in a commutator is dependent upon the total voltage used, the speed of rotation, and the number of brush sets. The voltage per segment is held between 5 and 15 volts and enough segments are used to keep the average tension per unit within this rather low upper limit.*

Accordingly, an extra heavy-duty generator or motor requires over a thousand segments of considerable size. With such an extensive use of electrical units of various sizes throughout the world, one can imagine the magnitude of the total quantity of mica thus consumed for punching commutator segments of numerous dimensions.

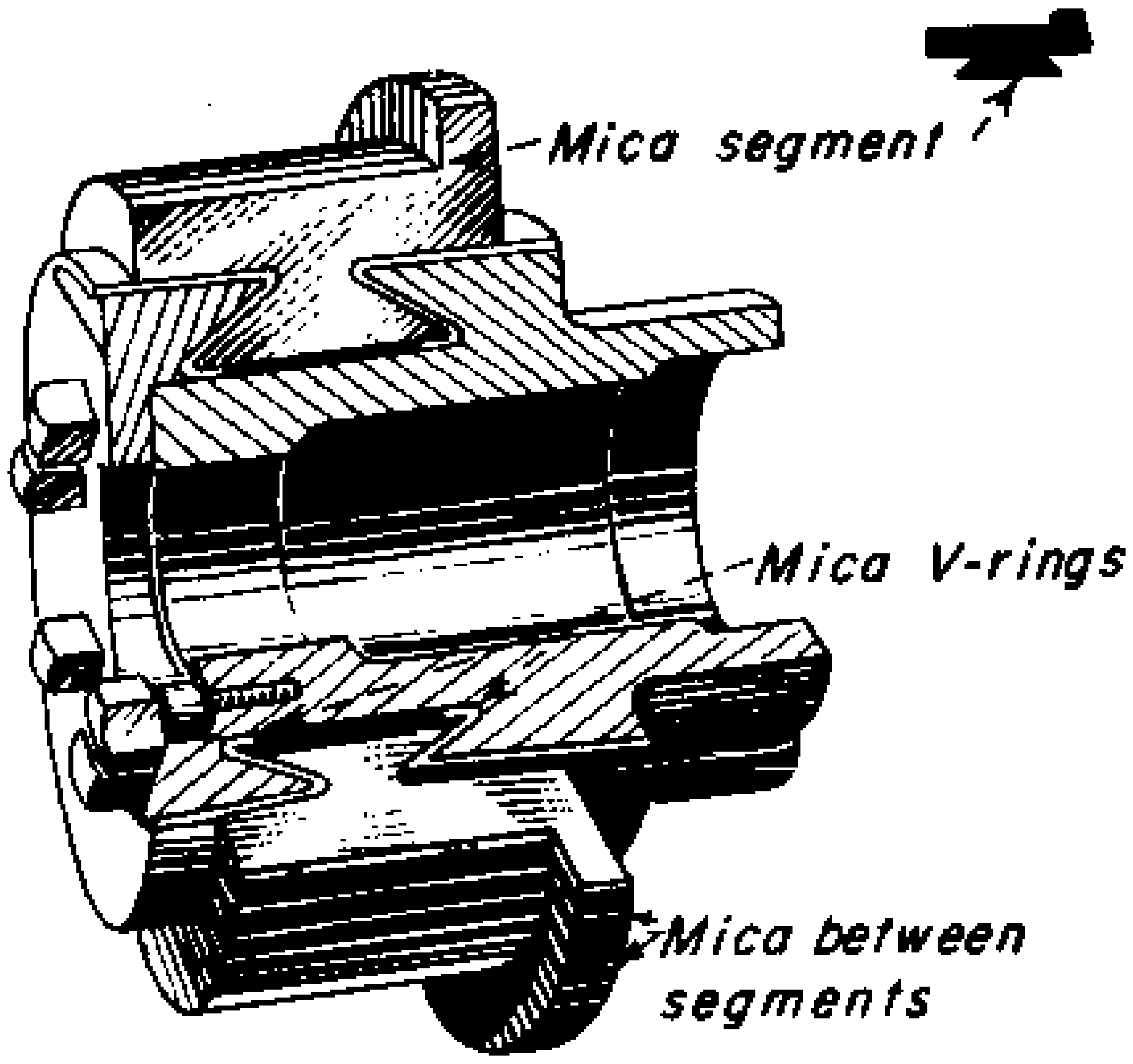

FIG. 72. Showing a commutator with mica segments and mica V rings. (Source: United States Tariff Commission, "The Mica Industry.")

Attempts are said to have been made to use some other materials or combination of materials as substitutes for mica for this purpose, but the results obtained so far have not been encouraging. Moreover, in considering substitutes for mica segments, cost is of

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* United States Tariff Commission report, "The Mica Industry," *Report* 130.

minor importance. In a small industrial motor costing say $200 (Rs.600/–) the mica segments represent a value of from 40 to 50 cents (Rs.1/5– to Rs.1/10–). Hence it is clear that mica (especially in built-up form), with its manifold properties, is the only substance known that can be suitably employed for commutator insulation.

Among other properties that this particular field of use demands of an insulator is hardness, which is found in mica. The hardness should not be greater than that of copper, preferably less.

Built-up mica segments of phlogopite mica splittings, produced chiefly in Madagascar and Canada, are said to be preferred to segments made of muscovite, because the former is softer than the latter, although this feature of phlogopite may be questioned and disputed. According to Mohs' scale, the hardness of muscovite varies between 2 and 2.4, while that of phlogopite varies between 2.5 and 3.0. According to Mr. Edward S. Dana, the softest phlogopite is as hard as the hardest muscovite. In practice, however, the results that are derived are quite contrary to what can naturally be inferred from the above mineralogical data.

As shown in Fig. 72, all the copper segments of a commutator are insulated from each other by intervening mica segments. The rapidly revolving surface of such commutator as a whole is subjected to the abrasion of the carbon brushes that press on it, resulting in constant wear of the same. But segments made of phlogopite wear down evenly with the copper segments, whereas muscovite segments often offer greater resistance to such abrasion, consequently tending to form projecting ridges of mica, which cause sparking and "chattering" of the brushes, thereby considerably impairing their operation.

Phlogopite has a distinctly softer feel than muscovite, probably because of its being more flexible and less elastic. Moreover, only the edge of a commutator segment contacts the carbon brushes and is therefore subjected to their abrasive action. Consequently, the wear on a commutator segment is across the edge and not on the face of the mica crystal. Hence the super-flexibility of phlogopite gives a yielding action, which allows it to bend and remain bent instead of elastically and stiffly resisting that tendency, as muscovite would behave when a small ridge of it is exposed.

Nevertheless, both types of mica, *viz.*, muscovite and phlogopite, are used in commutator segments. Phlogopite segments are commonly built into the commutator, turned, and left on the same plane with the surface of the commutator, because of its aforesaid behaviour. Muscovite segments, on the other hand, are not left flush with the surface but are undercut by gouging a narrow groove, a small fraction of an inch deep, between each two adjacent copper segments after the commutator has been assembled. Consequently no mica appears on the surface and the brushes touch nothing but copper.

It is interesting to note in this connection that some motor manufacturers, as a precautionary measure against the impediments of both uneven brush contact and wear, use phlogopite segments and also undercut them. It is obvious from the above that the undercutting operation does not involve any appreciable cost. Hence, phlogopite does not seem to stand as a serious detriment to the interest of muscovite as a competitor.

V Rings. In commutator construction, another important use of mica in built-up form is demanded in the shape of V rings (Fig. 66). Such V rings are fitted over the steel V edges at both ends of the commutator and insulate it from the copper segments that rest on and dovetail into it (Fig. 72). Most of these rings are stamped out directly from a flat piece of built-up mica molding plate, a procedure that puts the flexibility of mica to a crucial test, as it creases the mica sharply and at the same time crimps it.

The stamping of V rings (Fig. 73) is accomplished by using a sandwich of three circular washers, like disks, of hot-molding built-up mica plate. The outer diameter of both disks on the top and bottom and the inner diameter of the central hole in all the three disks remain the same, while that in the middle has a smaller outer diameter. This is done with a view to allot extra thickness to the ring at the critical point, where the angle of V occurs, to reinforce the same. Great accuracy is called for in all V-ring dimensions and they are manufactured in numerous sizes.

Some manufacturers list over 3,500 types of V rings with inside diameter * varying from ½ to 15 in., face varying from ⅛ to 4 in., and wall thickness varying from 1⁄32 to ⅛ in. Fig. 74 explains the above dimensions. Such rings with an inside point diameter up to 3 in. are usually stamped as explained, while larger sizes up to 28 or 30 in. and over inside point diameter are molded partly by hand, heated, and then pressed.* In 1942, the price of these V rings

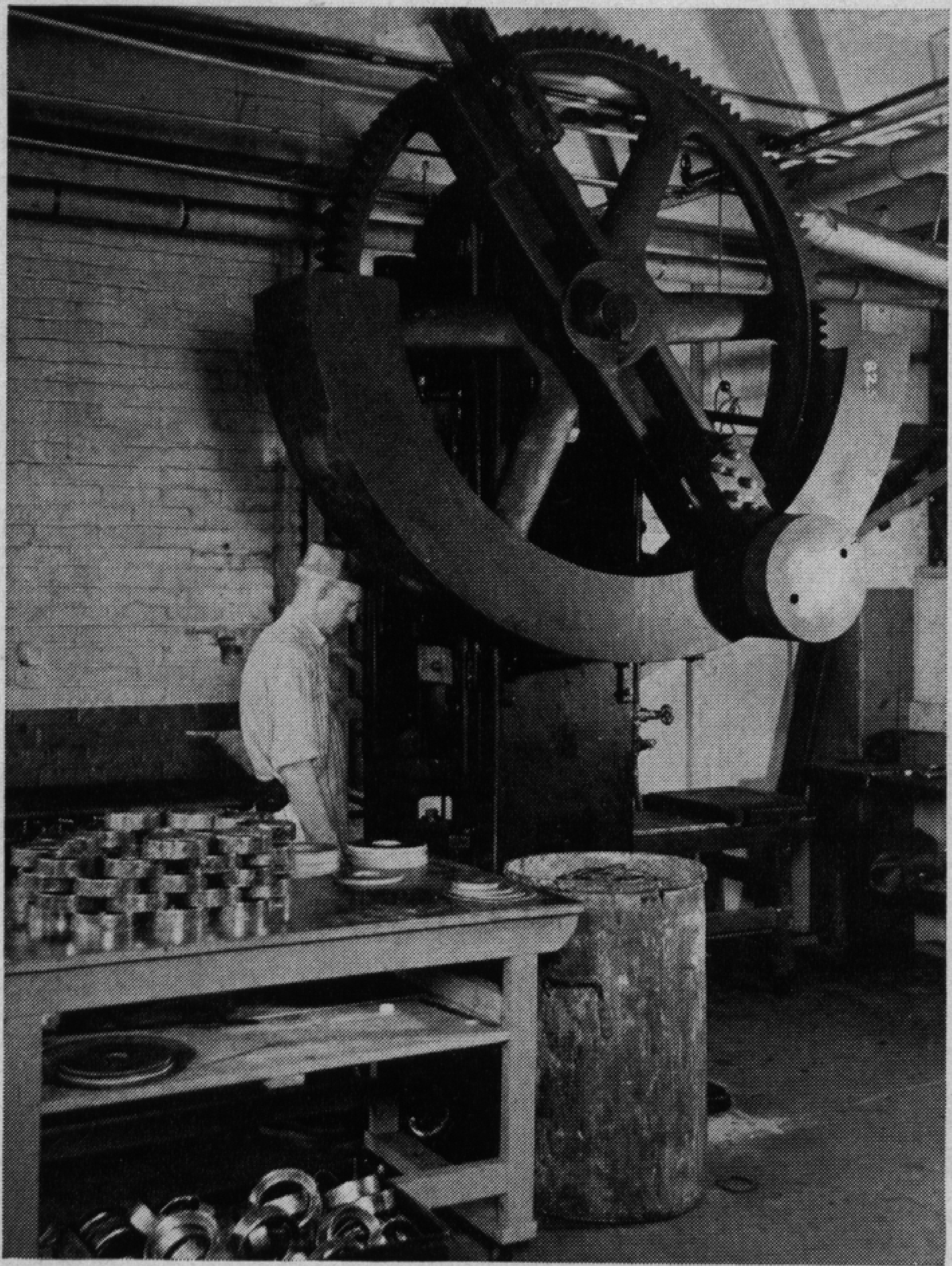

Fig. 73. Showing a large press for stamping V rings. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

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* United States Tariff Commission, "The Mica Industry," *Report* 130, p. 17.

varied from $17 a thousand of the smallest size, to $1,508 per hundred of the largest size (15 in. inside diameter).

Armatures. Built-up mica insulation plays a very prominent part as an insulator in the construction of armatures, the heart of the electric generator, which changes steam, water, or any other power into electric power by revolving relative to the magnetic field. In the structure of both generator and motor armatures, it is chiefly employed in the wrapping of the coils, in the slots in which the coil rests, and as pads or collars at each end of the armatures.

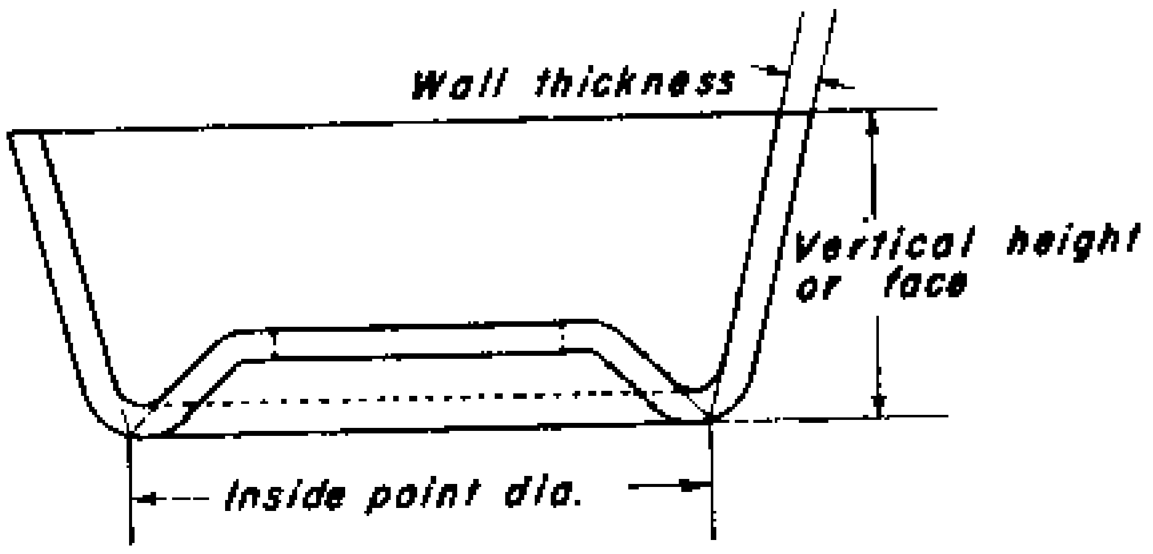

Fig. 74. Illustrating inside point diameter face and wall thickness of a V ring. (Source: Catalogue No. 24 of 1942 of Macallen Company, Boston, Massachusetts.)

Though in smaller units, built to operate at relatively low temperatures and low voltages, prepared paper or cloth insulation is generally used in lieu of mica, as recorded in the United States Tariff Commission's report (page 18),

> . . . such category includes all fractional horsepower motors, all automobile generators and starting motors, and industrial machines (except those with enclosed motors) up to considerable size. But of the total kilowatt capacity operated in 1934 by the 217 major electric utility plants in the United States, less than 3 per cent (885,000 out of a total of 31,500,000 kilowatts) were generated by so-called "small machines," *i.e.*, water-power and steam-power plants of less than 2,500 kilowatts and oil-engine plants of less than 500 kilowatts.

The availability of mica for armature insulation has made it possible to operate large generators at high temperatures. It is held by the manufacturers of these electric generators that machines built to operate at 66,000 volts or more are designed to withstand high temperatures and for that purpose mica insulation is essential.

TABLE 26 *

TYPES OF BUILT-UP MICA USED FOR INSULATION OF COMMUTATOR MACHINES

Commutator Machines—Ordinary and Heavy Duty †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
D.-c. machines (motors, generators, metadynes, amplidynes)	Commutator:		
	Bar separator	Commutator micanite	Muscovite or phlogopite ‡
	V rings	Molding micanite	Muscovite
	Collars	Molding micanite	Muscovite
	Armature:		
	Coil wrapping	Mica paper	Muscovite
	Slot liner	Molding micanite	Muscovite
		Flexible micanite	Muscovite
A.-c. machines:			
Commutator motors	Banding	Micanite	Muscovite
	Brush gear:		
Phase advancers	Brush-holder stud	Mica tubing	Muscovite
		Mica washer	Muscovite
		Mycalex	Mica dust
Rotary converters:			
Inverters	Field coils	Flexible micanite	Muscovite
		Mica tape	Muscovite

* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* D.-c. Motors: Aircraft, cranes and hoists, elevators and lifts; industrial drives—printing presses, textile drives, etc.; machine shops and tools; marine—deck machinery, winches, etc.; mills—flour and paper mills, steel mills, etc.; mining—coal cutters, hoists, etc.; motor-generator sets, motor transport—starter; power stations—ash-handling, fans, pumps, stokers, etc.; pumps, fans, etc.—sewage plants, wind tunnels, etc.; traction—compressors, fans.

D.-c. Generators: Aircraft; battery chargers; electric plating; exciters; lighting sets; marine sets; metal refining; motor-generator sets; power stations; radio-filament generators; traction supply; Ward-Leonard sets—mine hoists; rolling mills, etc.; welders.

Amplidyne and Metadyne: Mill and industrial drives; machine tools; railway traction.

‡ Limited use.

Tables 26 to 28 show in detail the various types of built-up mica used for insulation of different components of commutator machines of all sizes, *viz.*, ordinary, heavy-duty, extra heavy-duty, and small.

TABLE 27 *

TYPES OF BUILT-UP MICA USED FOR INSULATION OF COMMUTATOR MACHINES

Commutator Machines—Extra-heavy Duty †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
D.-c. motors	Commutator:		Muscovite
	Bar separator	Commutator micanite	
	V rings	Molding micanite	
	Collars	Molding micanite	
	Armature:		
	Coil wrapping	Mica tape Mica-asbestos tape	
	Slot liner	Molding micanite Flexible micanite	
	End turn insulation	Flexible micanite	
	Banding	Micanite	
	Brush gear:		
	Brush-holder stud	Mica tubing, washers or mycalex	
	Field coils, Main and Interpole:		
	Insulation to frame	Micanite collars	
	Turn insulation	Strips or sheeting	
	Layer insulation	Micanite	
	Protective taping	Mica tape	

* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Cranes and hoists; electric traction—battery vehicles, electric locomotives, motor coaches, mine locomotives, tramcars, trolley busses; iron and steel mills—billet pushers, car dumpers, cranes, crushing machinery, mill tables, ore bridges, ore unloaders, saws, screwdown gears, shears, transfer cars, etc.; submarine propulsion.

Transformers. The use of mica in the built-up form is said to be indispensable in the construction of transformers, according to the following opinion expressed in the United States Tariff Commission report (page 21) under the head "Transformers."

> Transformers, used for raising or lowering alternating current voltages, furnish an example of the strenuous duty performed by insulation, as high-

TABLE 28 *

TYPES OF BUILT-UP MICA USED FOR INSULATION OF COMMUTATOR MACHINES

Commutator Machines—Small †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
Motors, d. c. and a. c. (fractional horsepower) and Dynamos (small)	Commutator:		
	Bar separator	Block mica	Muscovite or phlogopite ‡
		Commutator micanite	
	V rings	Molding micanite	Muscovite
	Collars	Molding micanite	Muscovite
	Armature winding:		
	Slot liner	Molding micanite	Muscovite
		Flexible micanite	Muscovite
	Brush gear	Mica tubing	Muscovite
		Mica washers	Muscovite
		Micanite plates	Muscovite

* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Motors: agriculture—dairies, farms, etc.; aircraft—control devices, auxiliary equipment; automobiles, etc.—starters, windshield wipers; control mechanism; domestic appliances—drink mixers, kitchen mixers, vacuum cleaners; electrical equipment—controllers, rheostats, tap changers; fans and blowers—sirens, forge blowers, hand dryers, hair dryers, dust blowers; food retailing—bacon slicers, coffee grinders, etc.; laboratory equipment; office appliances—calculators, dictaphones, erasers, postage machines, registers, typewriters, cheque writers; portable appliances—film projectors, massage machines, sewing machines; portable machines—buffers, drills, grinders, routers, nibbling machines.

Generators: Aircraft—magnetos; automobiles, etc.; lighting sets; tachometers; domestic—house-lighting sets.

‡ Limited use.

and low-tension windings are brought in close proximity to each other. Electrical engineers have felt their way very gradually during the last quarter century toward the employment of higher and higher voltages for transmitting power. In the late nineties it was somewhat tentatively predicted that the day would come when current might be transmitted at as high as 10,000 volts, if a proper insulating medium could be developed. Today power is sent over wires from Boulder Dam to Los Angeles at a tension of 287,000 volts, with a minimum of loss, and it is possible to reach and employ this enormous pressure only in transformers insulated with mica. No other known insulation would permit of transformer voltages high enough to transmit so much power over such distances through wires small enough to be practicable.

In the case just cited, tremendous amounts of current at high voltage are involved. But even where small amounts are involved mica insulation must also be used. Small transformers for X-ray machines, for example, employ only small amounts of current, but at pressures up to 500,000 volts.

There are many transformers which operate on low voltages, in which other insulating material, phenolic resins, for example, may be used. As transformer tanks are generally filled with oil, the heat generated is well dissipated through the cooling effect of the oil, produced by contact of air with the corrugated outside surface of the tank.

Though not indispensable, mica is commonly used in transformers operating on 5,000 volts and below. Almost all the parts needing insulation are insulated mostly by built-up mica in various forms. A study of Table 29 will give the reader the various types of micanite used in insulating the different parts of a transformer.

TABLE 29 *

TYPES OF BUILT-UP MICA USED FOR TRANSFORMER INSULATION †

Type of transformer	*Component*	*Form in which mica is used*	*Type of mica*
Power........	Core laminations—insulation	Enamel containing mica particles	Mica dust
Distribution...	Coil insulation:		
	Primary to secondary	Flexible micanite	Muscovite
	Layer insulation	Mica paper or mica cloth	
	Protective insulation between coil and core	Micanite sheet	Muscovite
Welding......	Coil insulation:		
	Between primary turns	Micanite strips	Muscovite
	Primary to secondary	Micanite collars	Muscovite

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* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Electric supply: transmission, distribution, substations, factories, etc., rural, urban; railways—signal circuits; welding—arc welding, resistance welding.

Besides all that has been described in the preceding pages, built-up mica insulation plays no less important a part in the construction of other electrical machines, such as alternators, alternating-current salient pole machines, induction motors, control gears, etc. Almost all the conductors of these electrical units, both gigantic and small, which can aptly be called the backbone of today's industrial world, are insulated with built-up mica of one type or the other.

A study of Tables 30 to 33 will afford a fairly detailed picture of the various types of built-up mica employed to insulate the different components of the above machines.

TABLE 30 *

TYPES OF BUILT-UP MICA FOR INSULATION OF ALTERNATORS †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
Turbo alternators	Stator windings:		Muscovite
	Strand insulation	Mica tape	
	Conductor insulation	Micafolium or	
	Coil insulation	Mica tape	
	End windings	Mica tape	
	Terminal leads	Mica tape	
	Rotor windings:		
	Slot cell	Molded micanite	
	Slot insulation	Micanite strips	
	Conductor insulation	Mica tape	
	Turn insulation	Micanite strips	
	End conductor	Mica tape	
	End turn insulation	Micanite strips	
	Slip rings:		
	Insulation to shaft	Molded micanite	

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* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Main and auxiliary generating sets in steam power stations for industrial plants, mines and collieries, public utilities, railway systems, refineries, etc.; marine propulsion—turbo-electric ships; switch-gear testing plant.

TABLE 31 *

TYPES OF BUILT-UP MICA USED FOR THE INSULATION OF A.-C. SALIENT-POLE MACHINES †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
Synchronous motors	Stator:		Muscovite
	Conductor insulation	Mica tape	
	Coil insulation	Mica tape	
	End windings	Mica tape	
Alternators	Field coils:		
Motor- or engine-driven	Insulation from iron	Molding micanite	
		Flexible micanite	
Synchronous condensers	Turn insulation	Micanite strips	
	Slip rings	Micanite tubing	
		Molding micanite	
Alternators	Stator:		Muscovite
Water-wheel type	Strand insulation	Mica tape	
	Conductor insulation	Micafolium or	
	Coil insulation	Mica tape	
	End windings	Mica tape	
	Terminal leads	Mica tape	
	Field coils:		
	Insulation from iron	Molding micanite	
	Turn insulation	Micanite strips	
	Slip rings:		
	Shaft insulation	Molding micanite	

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* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Synchronous motors: air conditioning; blowers, compressors, fans, etc.; brickworks; chemical industry; marine—electric propulsion; mills—cement, flour, paper and rubber mills, lumber and sawmills, brass, steel, and other metal-rolling mills, etc.; mining and smelting—grinding and crushing, ventilation; petroleum industry; power station drives; motor generators for electrolysis, exciter sets, printing-press drive, mining, etc.; pumps—water, sewage, etc.

Alternators: Motor or engine driven type—emergency sets, small power stations, local supply, etc.; water wheel type—hydroelectric power stations.

Synchronous condensers: P.F. corrections.

TABLE 32 *

TYPES OF BUILT-UP MICA USED FOR INSULATION OF INDUCTION MOTORS †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
Induction Motors:	Stator windings:		Muscovite
Wound-rotor type	Conductor insulation	Mica tape	
	Coil insulation	Flexible micanite	
	Slot liners	Molding micanite	
	End windings	Mica tape	
Squirrel-cage type (stator only)	Rotor windings:		
	Conductor insulation	Mica tape	
	Slot liners	Flexible micanite	
	End windings	Mica tape	
Synchronous Induction Motors	Slip rings:		
	Insulation to shaft	Molding micanite	
	Slip-ring leads	Micanite tubing	
	Brush rigging:		
	Stud insulation	Micanite tubing	
	Insulating barriers	Micanite washers	

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* Source: "Notes on Mica, Its Properties, and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Applications.* Agriculture—farms and dairies; air conditioning—hospitals, schools, offices, etc.; brewing and distilling; chemical industry—drugs and explosives, general chemicals, glassware, etc.; collieries and mines; cranes and hoists; dock installations; food products—food processing, bakeries, etc.; laundries; lifts, conveyors, etc.; machine shops and tools; manufacture of—aircraft, general engineering products, textiles, plastics, rubber goods, etc.; marine auxiliary; mills—flour, paper, sugar, cement mills, etc., tube and rolling mills, steel mills, sawmills, etc.; oil refineries; power stations, public utilities, boiler houses, etc.; pulverizers, stokers, fans, pumps, etc.; printing presses, pumps, fans, etc.; railway repair shops; refrigeration plants; woodworking industry.

USES OF SHEET OR BLOCK MICA

The uses of sheet mica are limited to appliances calling for dielectric strength higher than the maximum that can be expected of built-up mica, low power factor, transparency, flexibility, higher heat resistance, etc. Hence the scope of its utility is narrower than that of built-up mica, though all that is produced in sheet or block

TABLE 33 *

TYPES OF BUILT-UP MICA USED FOR THE INSULATION OF CONTROL-GEARS †

Apparatus	*Component*	*Form in which mica is used*	*Type of mica*
Motor starters	Shaft insulation	Molding micanite	Muscovite
Drum-type controllers	Finger bar insulation	Micafolium	
Contactors	Blow-out coils:		
	Insulated coating	Mica-filled varnish	Muscovite
	Turn insulation	Mica washers	Muscovite
High-voltage	Operating coils:		
	Insulation	Flexible micanite	Muscovite
		Mica tape	Muscovite
Resistors Rheostats	Insulation to frame Element separators Terminal insulation	Mica tubing and washers	Muscovite

* Source: "Notes on Mica, Its Properties and Its Uses in the Electrical Industry," circulated by Associated Insulation Products, Ltd., London.

† *Uses.* Used in some types of motor starters for a.-c. and d.-c. motors; drum controllers for d.-c. motors; contactors for starting, reversing, control panels, etc.; resistors for starting circuits, power dissipation, heating, etc.; rheostats for motor and generator, field control, control circuits, etc.

Applications. Used in some types of motor starters for a.-c. motors; d.-c. motors; drum controller for d.-c. motors; contactors for starting, reversing, control panels, etc.; resistors for starting circuits, power dissipation, heating, etc.; rheostats for motor and generator field control, control circuits; application in general purposes (same as motors); also, cranes and hoists, electric traction, machine tools, mill drives, ship deck machinery.

form, which is only 25 or 30 per cent of the total production of S.D.B., is seldom not in demand.

As has been already explained, the use of sheet or natural mica in larger sizes (special and up) is avoided as far as practicable for reasons of economy. Even if the factor of cost could be ignored, adequate supply of larger sheets of natural mica cannot be relied upon, as their production represents only a fraction of the total output. In spite of these shortcomings, the use of sheet mica is indispensable in certain important electrical appliances.

That produced in sheet form finds a market sooner or later, and generally at prices higher than those of splittings, unfortunately characterized by their cheapness. Hence a producer tries his utmost to recover as much quantity as possible from his mine production as can be marketed as sheet or block mica. The only departure from this rule occurs when the current price, especially of book-packed splittings, allows sufficient margin in manufacturing over the current price of block mica of respective grades.

Of interest at this point is a description of some of the important electrical appliances and how mica is used in their manufacture.

Airplane-motor Spark Plugs. It is claimed that the use of mica, instead of porcelain, as the insulating medium in spark plugs has contributed substantially to making possible the present-day high-power airplane motors. All modern airplane motors, both for commercial and for military use, are equipped with mica spark plugs. In this particular usage practically all mica's valuable attributes are called into play.

The volume constancy (as described in the chapter on Characteristics of Mica) that mica possesses is an essential property of this part of an airplane motor, exposed to the high compression and high heat that are generated in the cylinders. The steel spindle that passes through the center from the upper terminal to the air-gaps at the bottom conducts a small current at a tension of 4,000 to 12,000 volts. This spindle or central electrode is primarily insulated by a wrapping of thin sheet mica generally of commercial stained quality, popularly known in the foreign trade as "cigarette mica." The thin wrapper of splittings about 0.001 in. thick (not more than 0.00012 in. thick) is rolled like cigarette paper round the center electrode, which is a little over ⅛ in. in diameter. In view of the flexibility obtained in such thinness, this is achieved very easily without breaking or cracking the film. The total thickness of the wrapping of the spindle, before all the layers are pressed together tightly by the tightening action of the brass bushing, is about 0.03 in. These layers of mica must resist the puncturing, destructive effect of an electrical stress of 20,000 volts. There may be a little leakage without any serious effects, but the wrapper must not break down under the strain.

A series of phlogopite mica washers is fitted over the mica-wrapped pin and tightly pressed against the pin shoulder near the bottom of the plug. Phlogopite is used here because it is exposed to great heat. Above the brass tightening cylinder and its tapered steel jacket another set of washers is fitted over the pin. These are of muscovite mica, and their outer circumference is exposed to the cooling effect of air. The whole assembly is then subjected to great pressure and held tight by crimping the recessed top of the pin over the brass head that forms the connecting terminal for the high-tension wire.

The plug described above is also provided with an attachment for the purpose of shielding the airplane's radio from the effect of the high-tension current of the spark plug. The increased use of "shielded plugs," which require much more cigarette mica than the unshielded variety, has been largely responsible for an increased demand for cigarette mica (wrapper mica).

Prior to World War II, the consumption of this mica was limited to a few thousand pieces only, and no appreciable quantity was then shipped from India, specifically as wrapper splittings. During the war, very large quantities of wrapper mica were supplied by India to the Joint Mica Mission, in various sizes ranging from No. 4 to No. 1 (described in detail in the chapter on Processing of Mica). In view of the uneconomic price level fixed by the Joint Mica Mission for both block mica and mica splittings, this new demand for wrapper splittings and wrapper mica, of different descriptions, acted as a strong stimulant to the industry, first, because prices offered by the Joint Mica Mission for this material were comparatively more attractive than those fixed for the other scheduled grades and qualities, and secondly, because it absorbed most of the production of stained quality mica from grades 4 to 1, which again represents a very important part of the mica produced by Bihar mica fields (especially in terms of value).

The statements contained in the United States Tariff Commission report with regard to the quality of mica that should be used for wrapping central electrodes, *i.e.*, that "the best quality of cigarette mica must be used in the manufacture of airplane spark plugs;

and only an extremely small portion of the total quantity of mica produced is of a quality that will serve this purpose" and "no other service (other than condensers) except spark plug cigarettes calls for such perfect mica,"* suggest that in the recent past (1938-1939) only high-quality mica was supposed to be suitable for use in spark plugs. But, in addition to buying stained quality wrapper splittings (which constituted the bulk of the Joint Mica Mission's purchases as far as this particular item is concerned), the Joint Mica Mission purchased from the Indian market for the United States large quantities of heavily stained wrapper mica (unsplit and cut to specified sizes 1¾ by 3¼ in. and upward). This emphasizes the fact that experience has altered the factor of quality to a considerable extent, and now a much lower quality than that used in pre-war days is suitably employed in the manufacture of airplane spark plugs. For some special cases, however, wrapper splittings manufactured from good stained quality mica still remain in use, as is obvious from the small-scale purchase of this quality by the Joint Mica Mission from the Indian market during the war.

The use of mica in airplane spark plugs is claimed to have been abandoned recently. But recent inquiries from the United States for wrapper plates of sizes other than those usually purchased by the Joint Mica Mission during the war tends to make the above claim ambiguous.

Radio Tubes. As recorded in the United States Tariff Commission report,* there were about 26 million radio receiving sets in the United States in 1938, each set consisting of a number of radio tubes. The production of radio tubes is reported to have been 78 million or even more. In 1929 sales of 69 million tubes in the United States totaled 172 million dollars. Modern civilization is demanding radios as never before and the radio industry is flourishing on a very large scale. A careful survey of the present-day radio-tube production of the world may, therefore, lead one to an astronomical figure.

Practically all the tubes in receiving sets contain from two to four small pieces of mica. Two pieces are known as "bottom" and "upper supports," or bridges, and the other two as "clips" or "spacers," as shown in Fig. 75. Hence from the above figures it is easy enough to imagine the quantity of mica required for the manufacture of what can aptly be called a colossal number of radio tubes.

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* United States Tariff Commission, "The Mica Industry," *Report* 130, p. 20.

The function of these mica supports is to hold the filaments erect, equidistant, and insulated from each other. The clips or spacers fit over the upper support or in some cases over the grids and, by contact with the sides, keep the whole assembly centered in the tube. Some mica supports or bridges are cut with two or more projections that tightly fit the interior surface of the tube, so that no clips are needed. There are numerous types of these radio tubes, and to meet the demands of various types of such spacers and bridges, they are punched in many different designs of mica pieces (Figs. 76 and 76*A*).

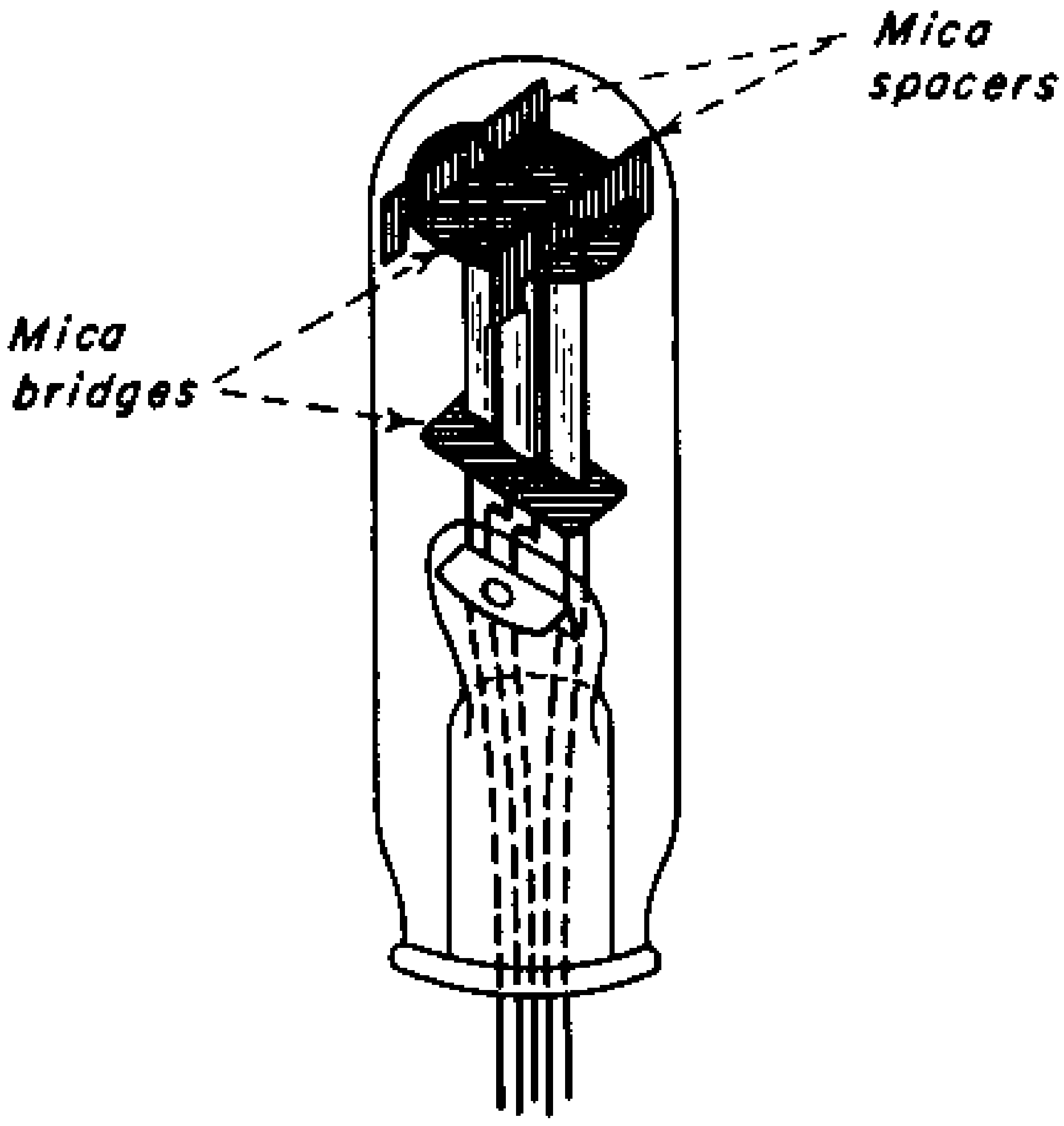

FIG. 75. Showing a radio tube with mica bridges and spacers. (Source: United States Tariff Commission, "The Mica Industry.")

Dr. G. R. Shaw, radio-tube engineer of the R.C.A. Manufacturing Co., in a communication to the United States Tariff Commission,* furnished the following explanation of the use and relative importance of mica in tubes.

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* United States Tariff Commission, "The Mica Industry," *Report* 130, pp. 21 and 22.

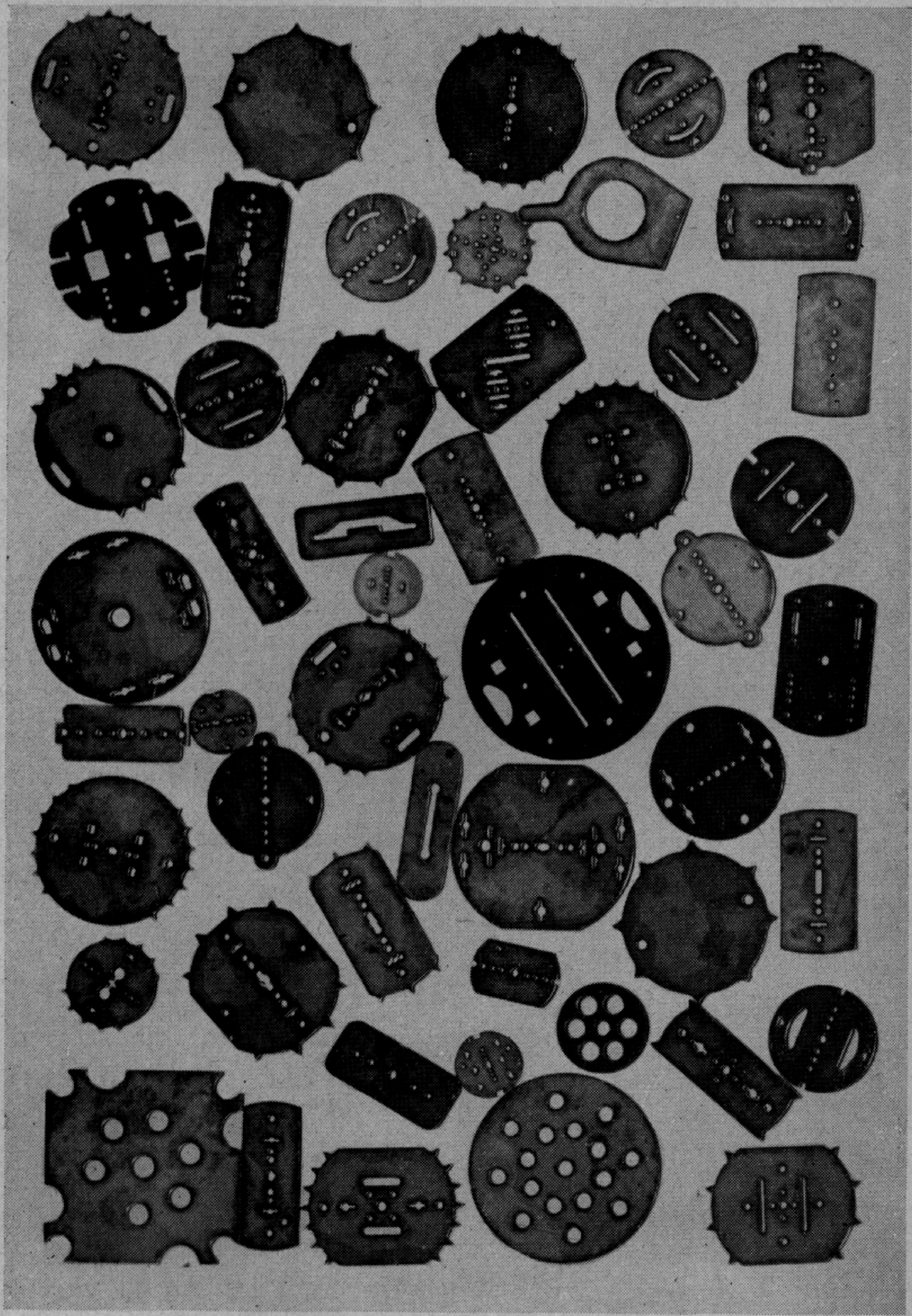


FIG. 76. Showing various radio bridges and spacers of different shapes and sizes. (Source: Ford Radio & Mica Corporation, Brooklyn, New York; Huse Liberty Mica Company, Boston, Massachusetts.)

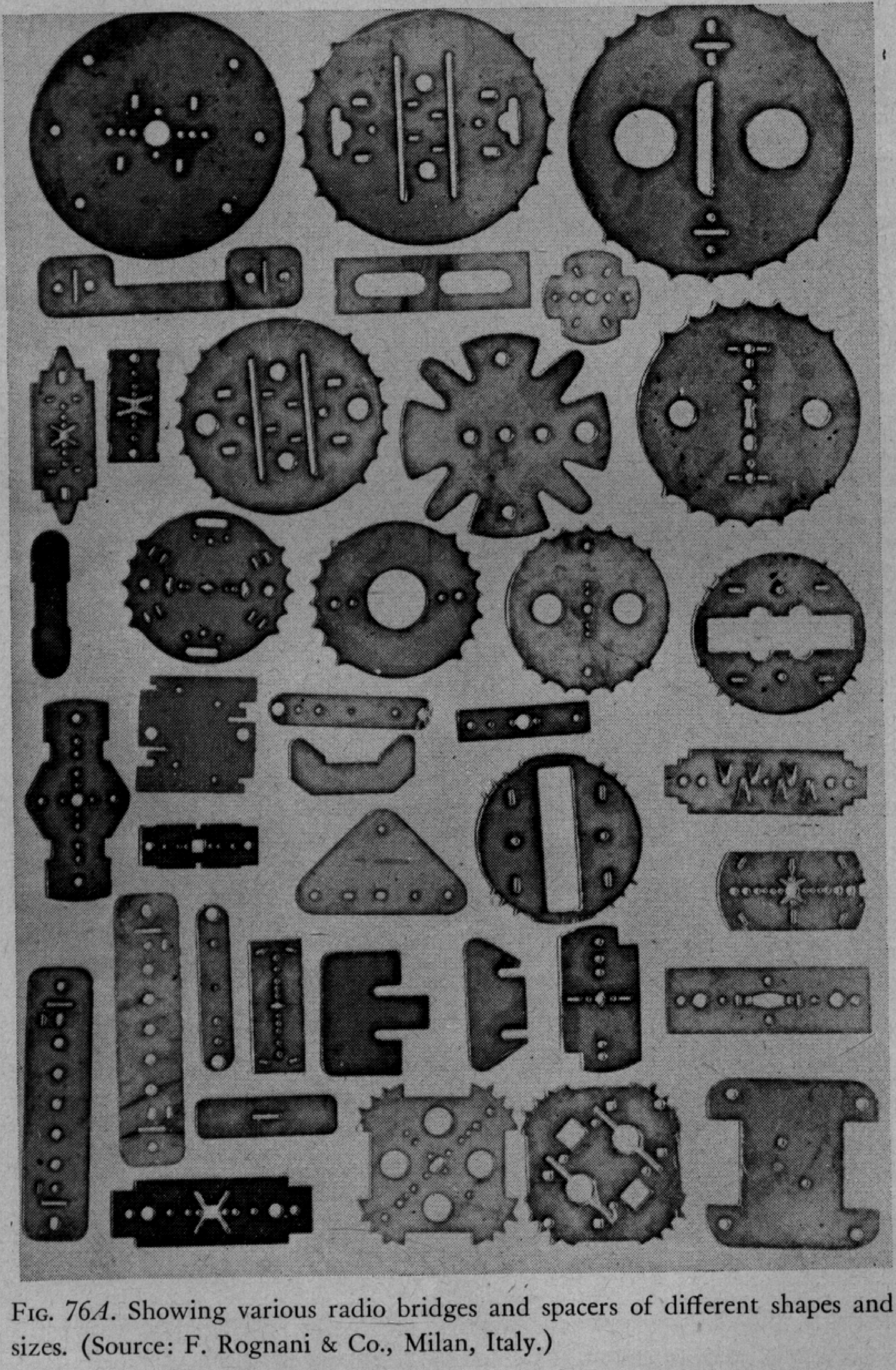


Fig. 76*A*. Showing various radio bridges and spacers of different shapes and sizes. (Source: F. Rognani & Co., Milan, Italy.)

> Practically all tubes of the receiving type use mica in some form or other. We use an India ruby mica, fair stained or good stained in quality. Thickness, of course, varies somewhat, depending upon the use to which it is put, but a range of 0.008 in. to 0.015 in. is most widely used. A tolerance of ±0.005 in. on outer dimensions is usual, but holes of smaller size cut into the mica may have a tolerance as low as plus or minus 0.001 in. There is no really satisfactory substitute for mica in all of its uses in tubes, but there are some places in which it is possible to make tubes of a satisfactory quality by the use of ceramics of various kinds. They usually present a greater problem in outgassing than does mica, and, of course, are usually more expensive. The mica which is usually used is, of course, of the muscovite type and while the use of phlogopite has been considered, it has not found widespread use. Transmitting tubes, where the heat dissipated is so great that it would cause the loss of water of crystallization under the vacuum conditions under which it must operate, require the use of ceramic-type materials.

Fabrication of radio-tube mica for radio bridges and spacers is an important industry in almost all countries making radio tubes. The most important of course is the United States. Such bridges and spacers are generally punched by a power press (Fig. 77). Though the punching operation is simple, the preparation of dies and punches for the bridges offers considerable difficulties and requires extraordinary skill. This is because the bridges particularly contain so many perforations and slits of various shapes and sizes, such as rectangular, triangular, circular, etc. Since the perforations and slits have a specific position and dimension, extreme accuracy in production is demanded. Hence constant checks on the product are made with the aid of optical instruments (Figs. 78 and 79) of the size and the spacing of the minute holes. In fact 95 per cent of the bulk thus manufactured must be strictly in accordance with consumers' specifications, or else the delivery stands the risk of rejection by tube manufacturers.

This particular use of mica finds a market for the smallest piece of sound mica that can be economically recovered from the bulk of crude mica produced from a mine, by sickle dressing. In pre-war days, mica of Nos. 6 and 7 grades in good-stained quality was employed for this purpose. But today the use of such high-quality mica has been practically abandoned, especially in the United States, and it has been suitably replaced by stained or even heavily stained qualities in the aforesaid grades. Bridge mica (popular name of mica used for punching radio bridges and spacers), in addition to being sound and hard, must be reasonably flat and free from all metallic stains. The radio-tube industry of the United States alone absorbs practically the entire bulk of such bridge mica produced in India.

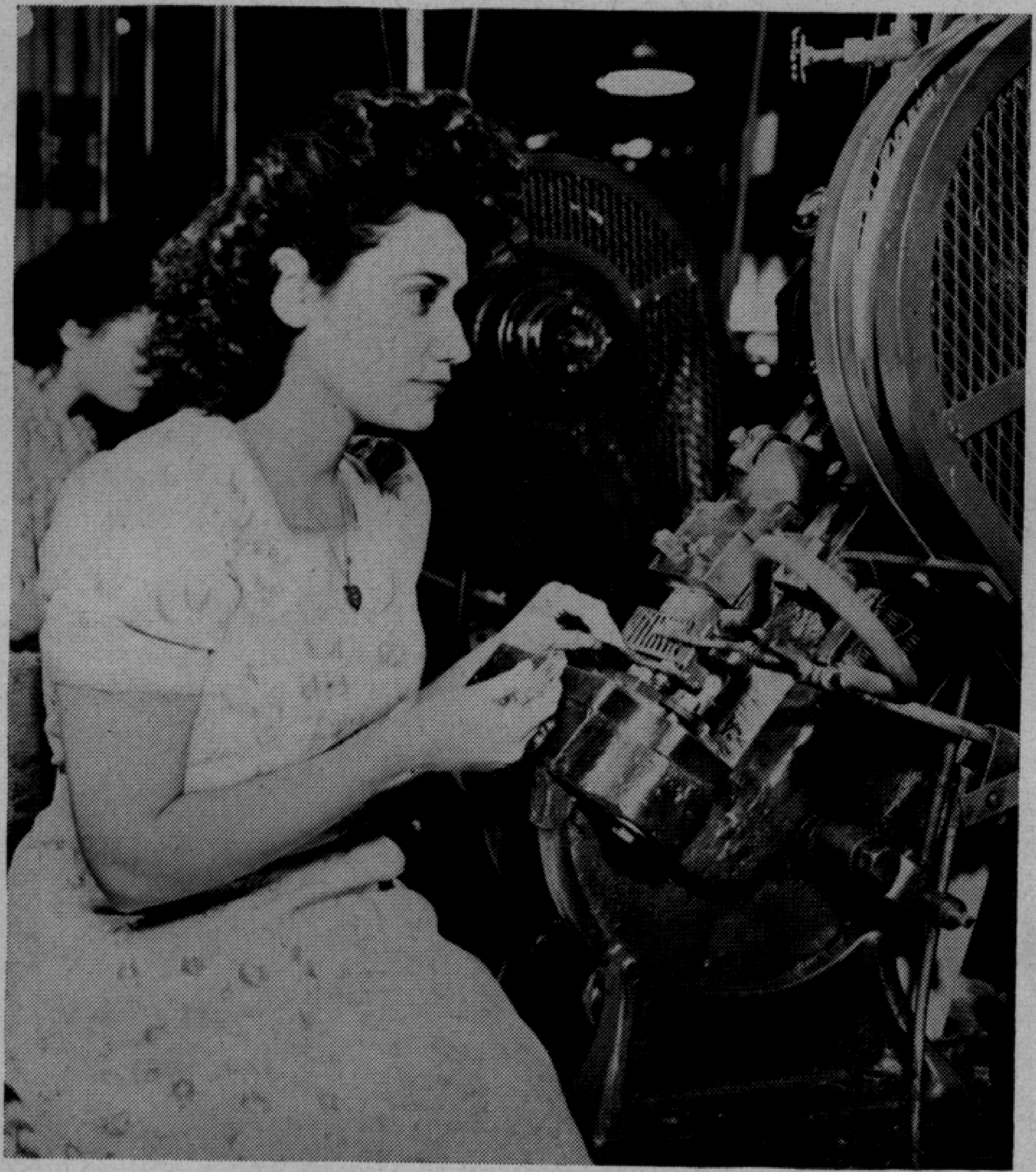


FIG. 77. Showing a small power-driven press employed for punching radio mica. (Source: "Ford Mica Manual," published by Ford Radio & Mica Corporation, Brooklyn, New York.)

Such mica used to be exported in random thickness (8 to 30 mils), but since the end of World War II, splitting of this mica to any range of thickness specified by the customer has gained wide popularity. The most popular ranges of thicknesses are 8 to 13, 8 to 14, or 8 to 15 mils, while there is an occasional demand for such mica split to 6 to 10 mils. The splitting of bridge mica to any specified thickness, allowing 5 to 6 mils tolerance between the maximum and minimum thicknesses, is easily done by hand, with the help of a slightly overgrown thumbnail or a small splitting knife. Mostly the splitting is done without the constant use of a micrometer by each splitter, though in a department consisting of 40 or 50 splitters, a couple of micrometers are kept for the supervisors to check the accuracy of the work done. Usually only 85 per cent of the bulk exported is guaranteed to be within the specified range of

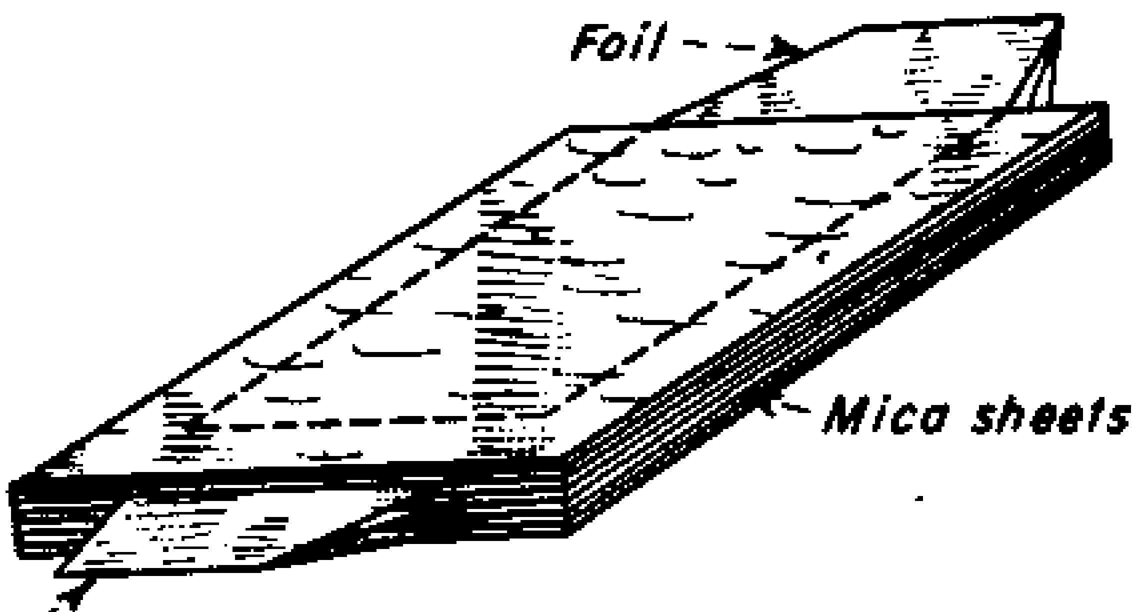
Fig. 78. Thoroughly trained inspectors using modern optical equipment make for accuracy in alignment so important to engineers working on critical-type tubes. (Source: "Ford Mica Manual," published by Ford Radio & Mica Corporation, Brooklyn, New York.)

thickness, while the remaining 15 per cent may be slightly under or over the specification, which finds the approval of the foreign consumers.

Radio Condensers. Radio condensers operating under high-frequency voltage, as well as trimmer-type condensers, absorb the largest quantity of better quality sheet mica (good stained and better) practically in all sizes (mostly grades 6 to 3). This represents between 30 to 35 per cent of the total value of mica produced, especially by the Bihar field.

FIG. 79. The metallurgical microscope, with filar micrometer attachment, gives the greatest known accuracy in measuring diameter hole sizes. (Source: "Ford Radio Manual," published by Ford Radio & Mica Corporation, Brooklyn, New York.)

The unique services rendered by mica in the operation of a radio condenser by virtue of its inherent attributes have been discussed in detail in the chapter on Characteristics of Mica. The function of a radio condenser, like that of other condensers, is to receive a certain amount of electric energy, store it for half a cycle, taking perhaps one-millionth part of a second, and then redeliver it with as little loss as possible. Such power loss in a radio transmitter condenser should be kept as low as possible, within 0.02 to 0.04 per cent, because the fatal effect of a higher power loss in the dielectric of a transmitting condenser is manifested by overheating of the dielectric. For the higher the power factor, the greater the heat generated, and as the temperature rises the power loss increases, thus setting up a progressive deterioration, which ultimately ruins the condenser. This is easily averted by the use of the finest quality condenser mica plates, the power factor of which is always found to remain well within the desired range of 0.02 to 0.04 per cent. In other words, the total energy delivered by a condenser with the finest quality mica plates used as a dielectric is invariably found to be 99.96 to 99.98 per cent of the energy delivered to it.



Each layer of Foil placed between two sheets of Mica film. Ends of Foil protrude in alternate directions and are bound together outside of Mica sheets and connected to lead wires.

FIG. 80. A condenser. (Source: United States Tariff Commission, "The Mica Industry.")

As shown in Fig. 80, the construction of a condenser is quite simple and consists of alternate layers of dielectrics and conductor foils (mica being the essential dielectric in the case of radio condensers). Each layer of foil is placed between two sheets of mica films, while the ends of all the foils contained in a condenser protrude in alternate directions and are bound together outside of the mica sheets, to be connected to lead wires.

Such condensers or capacitors are made in numerous shapes and sizes and for numerous uses. Though many materials are used as dielectrics, mica is the most preferred and is indeed an indispensable dielectric for use in radio condensers, in transmitting, receiving and trimmer types.

Mr. Robert F. Feidl, engineer for the General Radio Company, Cambridge, Massachusetts, in a communication to the United States Tariff Commission, explains the use and importance of mica in radio condensers as follows:

> The use of mica in condensers depends upon the electrical properties of mica. Its extremely low power factor, less than 0.0005, combined with its high dielectric constant of about 5, make it almost unique among natural minerals. The arrangement of its cleavage planes allows it to be obtained in sheets a few thousandths of an inch thick, which is ideal for use in electric condensers. There is no substance at the present time which is its equivalent for this use. Fused quartz and some of the ceramics such as ultra-steatite and Alsimag 196 have as low losses as mica but cannot be obtained in thin sheets. While it is possible that future developments will produce a competitive synthetic material, it is not in sight.

Mica used for condensers in receiving sets is never subjected to more than 600 to 800 volts; consequently the resultant heating effect is relatively small. Hence the mica used in such condensers may be of comparatively lower quality than that used in transmitter condensers, operating under very high voltage (say, up to 20,000 volts) and high frequency.

The mica films used in condensers are commercially known as "condenser films" or "plates" (the latter being cut to any specified size) in India and elsewhere. Before World War II, the manufacture of such condenser films or plates was conducted on a rather small scale and was strictly confined to a very few mica producers and manufacturers in India. But as a result of the Joint Mica Mission's policy of unrestricted buying, the manufacture of condenser films especially has gained wide popularity in recent years. India is confirmed to be the producer of the finest quality condenser mica, and large quantities of condenser films split to specified thickness, and some quantities of fabricated condenser plates, are shipped to foreign countries.

The statement that the highest quality mica is used in transmitter condensers may give birth to some misgivings, and one might be led to think that the use of as high quality as clear and slightly stained mica for such purposes may be warranted. But for this purpose, first-quality films manufactured from fair stained quality mica generally meet the requirements. Moreover after splitting very little or no difference can be detected between films split from the highest quality, *i.e.*, Clear & S.S., and those split from fair stained mica, though the use of the latter makes a great difference in cost.

As recorded in Appendix D (Bureau of Standards—Power Factors and Dielectric Constants) of the United States Tariff Commission report, though the dielectric constant of stained quality muscovite, is, on the average, similar to that of clear muscovite, the power factor varies from 0.06 to 8.36 per cent, thus making it unusable for condenser purposes. Apart from the question of power factor, another important point governing the use of mica for condenser purposes is its purity, *i.e.*, freedom from metallic stains. But stained quality mica generally contains fine metallic stains or specks, some not easily detectable by the naked eye, which make it incapable of withstanding high voltage without puncturing at the points rendered weak by the metallic stains or specks.

As is often seen by the splitting of some stained or even black spotted mica blocks, these defects crept in only after the crystallization of the different films of mica and before their consolidation into a compact form as mica books. In many cases, it is found that such defects are not uniformly distributed throughout the thickness of the piece. After splitting such pieces, some films perfectly usable, even as best quality condenser films, can be recovered, though in such cases the average yield of condenser films is very low. Thus the recovery of the small percentage of films that is usually present in the bulk of such lower quality mica is mostly made impracticable, by the factor of cost.

*Long-distance Telephones.** Added to the world-wide use of mica condensers, in both radio transmitting and receiving sets, is its usefulness in the long-distance telephone system. The telephone repeating stations, or long-distance centrals, require more or less the same service of mica condensers as that required by radio broadcasting. On the receiving end of the telephone, however, which operates on very small voltage, paper condensers satisfactorily meet the requirements. But there are thousands of relay or repeating stations throughout the world, for long-distance communications. High voltages are impressed upon the transmitters in such stations through mica condensers. Long-distance service, spanning the ocean, calls for the use of condensers containing thousands of small pieces of mica and thus contributes substantially to the increasing of the multifarious uses of mica.

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* United States Tariff Commission, "The Mica Industry," *Report* 130.

Armatures. In some special cases, where very high heat is generated during the course of operation of generators or motors, rendering the use of built-up mica impracticable, sheet mica is used for armature insulations. Typical of such class of generator or motor are fully enclosed machines, such as some enclosed-type motors to be used underground in a mine where protection against moisture and dust becomes essential.

The heat generated in such motors is confined in the unit itself and so cannot readily escape. Motors and generators designed for use in hot climates, such as prevail in parts of India, Ceylon, and other countries, also contain natural mica armature insulation.

All that has been discussed so far, with regard to the uses of mica, relates mostly to the valuable services that it renders to world industry in general. But the part that it plays in catering to the ease and comforts of individuals in all nations is also of importance, though not regarded as indispensable. The use of natural sheet mica, apart from built-up mica, in domestic electrical appliances, such as electric flatirons, coffee percolators, waffle irons, toasters, water heaters, curling irons, and many other appliances in household use, is an important factor providing a market for practically the entire production of lower quality mica in sizes No. 4 and above. The mica used for such purposes is popularly known in the Western countries as "electrical mica," meaning anything between black spotted, heavily stained, and stained qualities, though lately densely stained quality also has gained much importance in this line.

A detailed discussion on this particular aspect of its uses, however, does not fall within the scope of this book. Many of the appliances mentioned above require mica in other than their terminal parts, and since there are two general types, one prominent example of each may suffice to give the reader an insight into the subject. The two types are as follows:

1. Apparatus in which the mica is firmly held and supported or pressed on both sides by other material and is therefore inaccessible to outside contact or disturbance, as in an electric flatiron.

2. Appliances in which the mica is self-supporting and exposed, as in toasters.

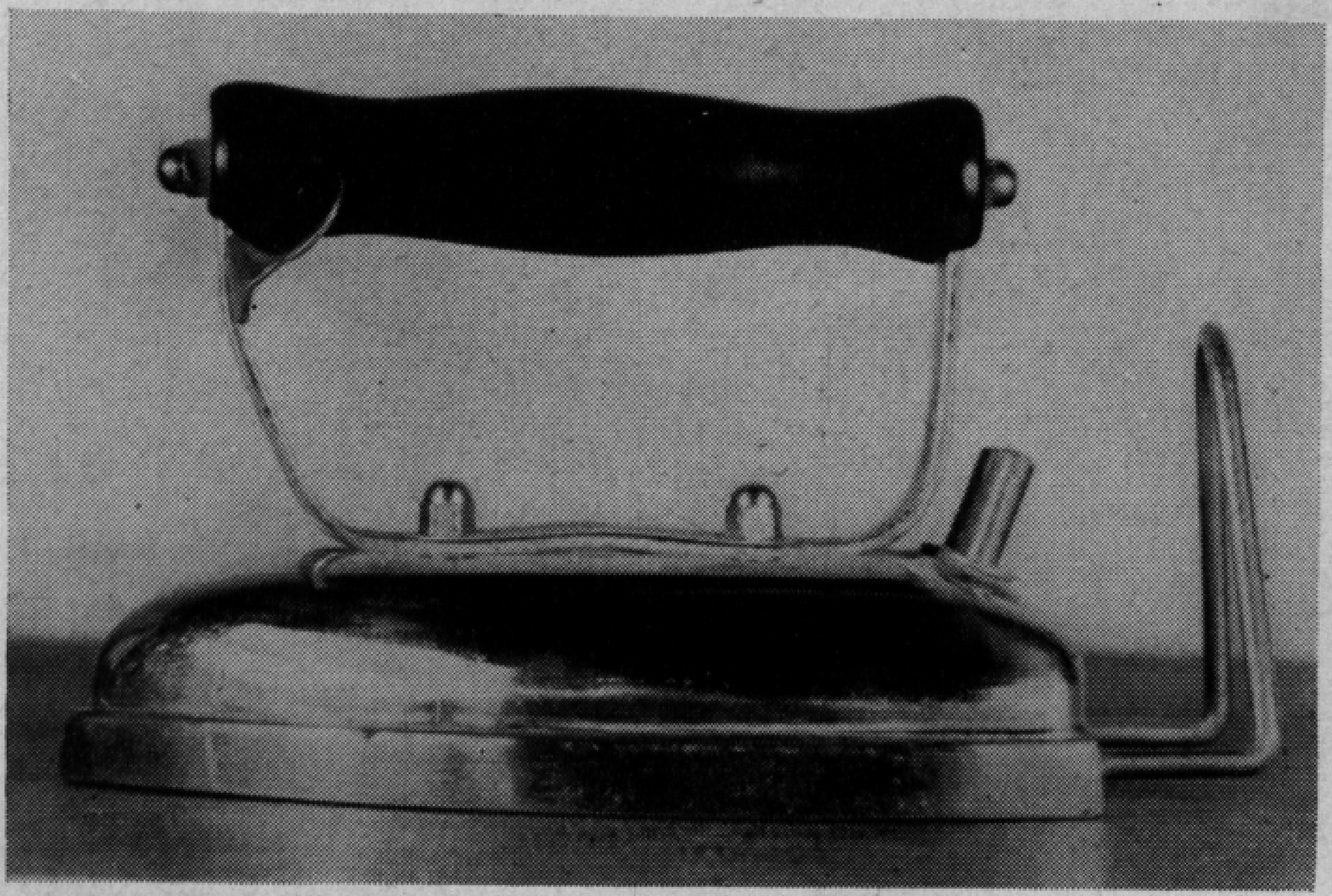

Fig. 81. An electric flatiron.

Electric Flatiron (Fig. 81). The heating unit in an electric flatiron consists essentially of three pieces of mica punched to a shape that will more or less conform to that of the bottom plate of the iron. The upper and the lower sheets, which may be either sheet mica or built-up mica, are for insulation purposes only, while the middle piece (or pieces, since this section is generally though not always made of two half pieces) is the carrier for the flat ribbon, like nichrome resistance element, that is wound around it. This element-carrying unit is nearly always of pure sheet mica, though there are special types of built-up mica made with inorganic binders that stand up well under the severe heat encountered in the service. As shown in Fig. 82, the three mica pieces constituting the heating plant are either riveted together or enclosed as a unit in a thin stovepipe-iron envelope of the same shape, and the entire assembly, which is not much over 1/32 in. thick, is supplied to the retail trade as a replacement part.

In some makes of irons, where the upper and the lower insulating pieces are of built-up mica, the bonding material (such as shellac) is quickly dissipated by the heat generated in service, and the two insulating pieces are reduced to layers of loose splittings. Hence, unless for purposes of renewing these insulation pieces, the flatiron should never be dismantled.

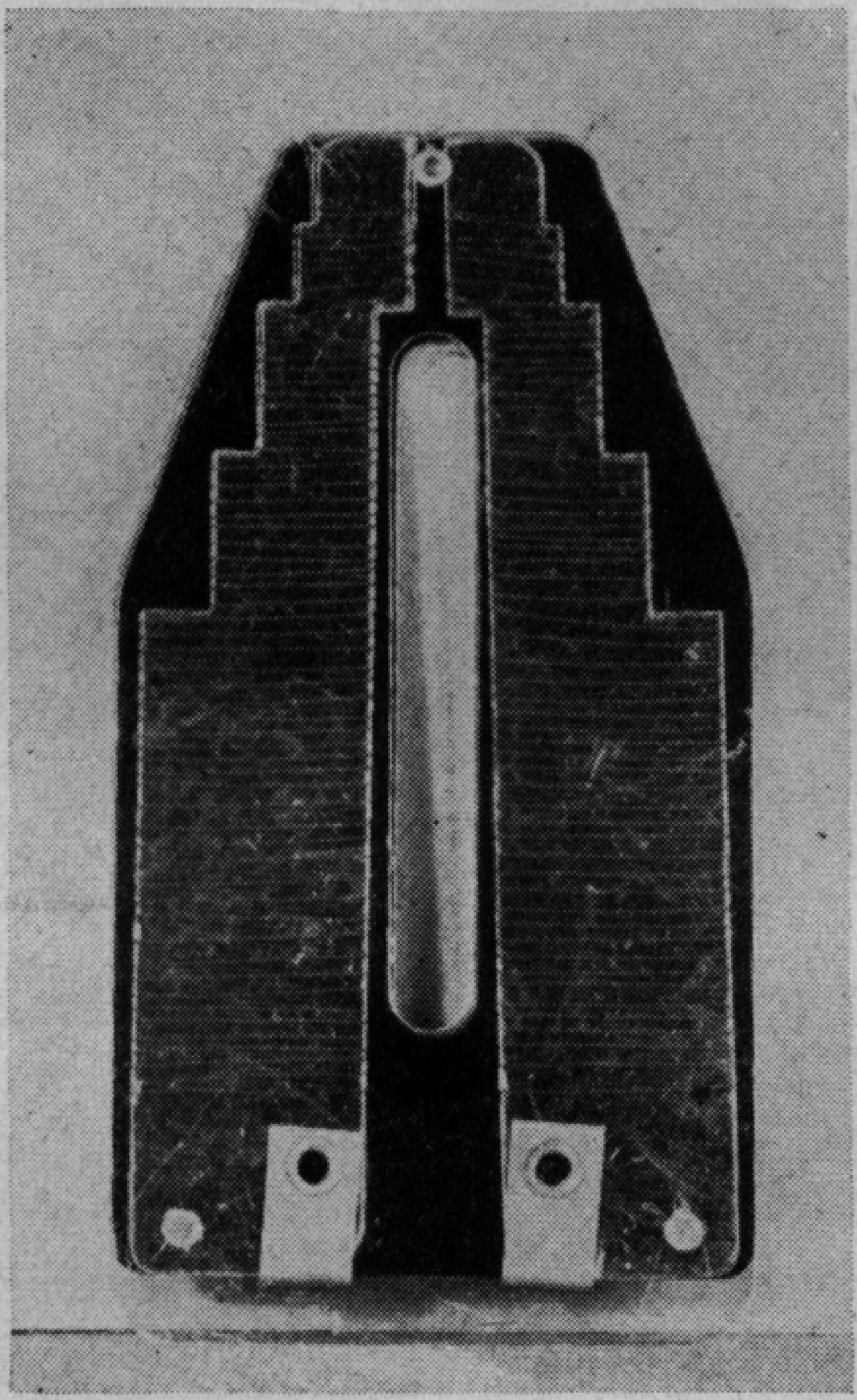

FIG. 82. A complete heating unit of an electric flatiron, consisting of two pieces of mica as insulators with another piece in the middle embodying the nichrome resistance element.

*Toaster.** The heating element of an electric toaster is similar in principle to that in a flatiron. One or, as shown in Fig. 83, two rectangular pieces of mica embodying nichrome ribbon winding are heated to redness by the electric current for radiating heat. But, in this case, such heating element or elements, instead of being held confined between the rigid coverings (as in the case of the electric flatiron), usually stand erect and are exposed to the air. Hence such heating element or elements must essentially be strong and self-sustaining. Moreover, since the heating element in this case is held erect, both by the base and by the top cover of the toaster, and is exposed to the air without contacting any metallic part, it is not insulated on either side by mica pieces, as in the case of the electric flatiron.

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* United States Tariff Commission, "The Mica Industry," *Report* 130.

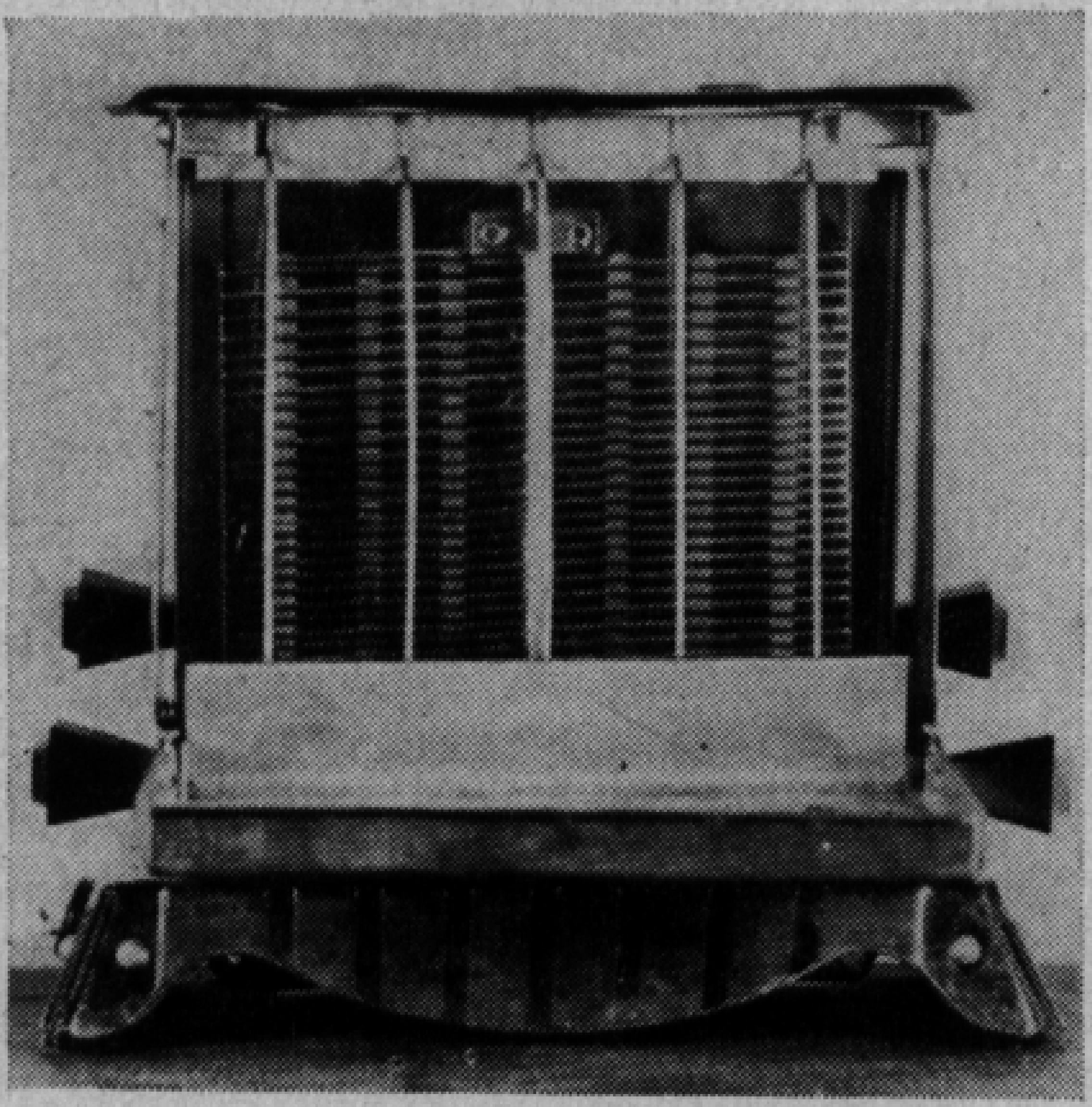

Fig. 83. An electric toaster, with two rectangular pieces of mica standing side by side and carrying the nichrome resistance element.

Usually electrical quality pure sheet mica is used as the base for winding the nichrome ribbon, though heat-resisting built-up mica, containing inorganic binder, can also be suitably employed. The use of rectangular strips of 2 by 5 in. or 4 by 5 in. or even more is called for, which is rather expensive. Hence it is common practice among the manufacturers to employ two or three pieces riveted together or perhaps merely overlapping each other, instead of one full-size piece of sheet mica.

Miscellaneous Uses. Apart from the various important uses described in the preceding pages, there are numerous other miscellaneous uses of mica, such as for stove windows, lantern chimneys, furnace peephole covers, nonbreakable goggles, boiler gauge glass, compass cards, etc., calling for mica's transparency. Though a particular use of such nature may not consume substantial quantities of mica, the collective effect of the same in respect to the quantity consumed is appreciable. Some of its important miscellaneous uses are described in some detail in the following paragraphs.

Boiler Gauge Glass. Mica is used in place of glass in high-pressure submarine boiler gauges. Besides its nonbreakable nature and flexibility, its transparency and chemical inertness play an important part in its use for this purpose. This particular use affords an outlet for most of the larger grades (special and up) of high-quality mica, for mica thus used must necessarily be as transparent and flat as possible.

The Joint Mica Mission purchased considerable quantities of mica selected to cut rectangles of various specified sizes (from 1⅝ by 8⅝ in. to 2⅜ by 14¼ in.) for this purpose, in qualities good stained, fair stained, and Clear & S.S. Though purchases of such mica are made in terms of pieces selected to cut a particular rectangle of given dimensions, in the final punching the extremes of such pieces are made semicircular.

Compass Cards. Only highest quality mica of large sizes, capable of yielding a circular disk of 6 to 9 in. diameter, can be employed for this purpose. This particular use demands the maximum amount of flatness transparency and absolute freedom from air bubbles or minutest metallic stains. Such conditions can be fulfilled only by pieces selected from clear quality mica. Circular disks thus stamped are employed for manufacturing bromide plates, with a view to photograph the compass graduations to be used as compass cards.

Other Uses. "Art" lamp shades made of thin plates of built-up mica have gained popularity during recent years. The artistic effect of a strong light behind a lamp shade of micanite is caused by slight variations in thickness of the layers of mica splittings and the shellac or other binder, which give a translucent mottled appearance of many tones, from near white to deep red or ruby.

In addition to the above, large quantities of mica are used as fuse-plug covers. These are known as "disks" and provide a market for mica mostly of grade 7. As a matter of fact, substantial quantities are regularly shipped, mainly to the United States, for this purpose, either as punched disks of some specified diameter ($1\frac{1}{16}$ in. being the most popular size), or as mica selected to cut circles of various diameters (generally the lowest being 1 in. in diameter). This, together with the use of small grades of mica in radio tubes, finds consumption for practically the entire Indian production of such mica in one country alone, *i.e.,* the United States.

Another, and quite important, use for mica disks is in the necks of large electric-light lamps, where its function is to protect from excessive heat the lower part of the stem and lead-in wires. Lamps of 300 watts and over employ these mica disks.

Washers of innumerable sizes are also manufactured either from poorer qualities or, mostly, from heavily cross-grained mica. Thus the only use that such cross-grained mica finds is for punching washers of various sizes. India punches such washers in large quantities in all sizes, generally ranging from $\frac{1}{2}$ in. outer diameter by $\frac{3}{16}$ in. inner diameter to $4\frac{21}{32}$ by $3\frac{1}{8}$ in.

Neon Lights. A fairly common, though not essential, use for mica occurs in the glass cylinders which enclose the electrodes of neon-light signs. Some manufacturers use mica sleeves, completely surrounding the electrode, to keep it from touching the glass, while others accomplish the same purpose by riveting two small circular mica disks, one on each side of the metal electrode itself. These disks are large enough to project beyond the diameter of the electrode and hold it centered by touching the glass cylinder at four points.

Ground Mica *

The uses of ground mica are of much less importance than those of the other two species, sheet mica and built-up mica, though they provide a market for mica waste or scrap and invest it with some economic value. There are two methods of grinding mica, wet grinding and dry grinding.

Wet Grinding. In the absence of any personal knowledge of this process, the writer cannot do better than quote the lucid and graphic description given by Mr. F. W. Horton of the United States Bureau of Mines (contained in the United States Tariff Commission report, on "The Mica Industry," pages 111-112).

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* Most of the informations and tables contained in this chapter are compiled from the United States Tariff Commission report, "The Mica Industry."

> Wet grinding is done in chaser mills consisting of annular steel or wooden pans up to 10 ft. in diameter and 40 in. in depth, in which wooden rollers rotate or horizontal arms revolve about a central shaft. The bottoms of the pans are lined with and the rollers made of end-grain wooden blocks, oak, maple, and black gum being preferred. The mills may be equipped with 2, 3, or 4 rollers ranging in diameter from 30 to 40 in. The roller faces are generally 20 to 24 in. wide, and the rollers are so arranged that they can be raised or lowered according to the depth of charge in the mill. Steel plows following each roller turn the charge to present new material to the grinding action of the succeeding roller and to keep the mica in the path of the rollers. The mills usually operate at 20 to 40 r.p.m., varying with the dimensions of the mill and the weight of the charge, and consume about 20 hp. Complete grinding of a 1-ton charge of mica requires 4 to 8 hr.; the time varies with the physical character of the mica and speed of the mill. The mica, unless it is clean shop scrap, is washed thoroughly to remove fine rock and dirt before it is ground. Grinding is started without water, but as the mica breaks up, water is added gradually to form a stiff paste and the grinding is continued under carefully regulated conditions until the charge is completely ground. The friction generated in the charge produces so much heat that the water actually boils, and care must be taken to prevent the mica from becoming too dry and "burning." The water content of the charge must therefore be watched carefully. If too much water is used proper grinding is precluded, and if too little is used the mica will burn and lose its sheen.
>
> The ground charge is sluiced from the mill into wooden sand boxes or launders, where the gritty impurities and coarse mica settle. The overflow carries the fine mica to wooden vats, where it is allowed to settle and the clear water is siphoned off. The mica sludge is then transferred direct to steam tables, or it may be filter-pressed before drying. The dried mica is run over a vibrating scalper screen, usually of about 60- or 80-mesh, to remove heavy particles that would injure the fine silk cloths of the bolting machines on which it is sized. The bolting machines are similar to those employed in bolting flour; replacement of the expensive silk cloths is a large item in the cost of screening mica. The mica is bolted through 160- to 300-mesh cloths according to specifications and the oversize is returned to the mills for regrinding. Normally 80 to 85 per cent of the mica is recovered as a finished product. In all of the operations great care is exercised to keep the mica clean and free from oil and iron stain.
>
> A grinding plant with three mills makes about 2 tons finished product in a 10-hr. day. Seven men are employed; one fireman, one millman, one

vatman, one filter-press man, two driermen, and one screen and bag man. About 85 hp. is required to operate the mills, pumps, elevators, and screens in such a plant, and approximately ½ ton of coal is burned to dry each ton of finished product.

The following screen analyses [Table 34] show the fineness of two standard brands of wet-ground mica for use in decorating wallpaper. The weight per cubic foot of the ground mica is also given.

TABLE 34

Weight per Cubic Foot of Ground Mica

Through	*Brand* 1	*Brand* 2	*Through*	*Brand* 1	*Brand* 2
60-mesh.......	100.0	100.0	200-mesh......	97.2	94.0
80-mesh.......	99.5	99.9	325-mesh......	87.7	76.3
100-mesh.......	99.0	99.7	Weight, lb. per cu. ft........	14.0	15.5
150-mesh.......	98.2	97.5			

Dry Grinding. Mica scrap ground dry is a less expensive product than the wet-ground material. Dry grinding is accomplished in many kinds of mills, the favourite type being a hammer mill, occasionally in two stages. Waste or scrap mica employed for this purpose must be washed as free as possible from adhering grit and clay by stirring and settling in successive tanks. The clean wet bulk is dried before being subjected to the grinding operation. The final ground product thus obtained is screened through a specified mesh before packing in gunny bags. Though the demand for products of a given mesh varies among consumers, the popular standards are 80, 140, and finer than 140 (much of the latter passing a 250-mesh screen).

Table 35 shows the gradual growth and evolution of the ground-mica industry in the United States, with an abrupt leap in the year 1935 and rapid development in the subsequent years.

Uses of Wet-ground Mica. By far the largest quantity of ground mica thus produced finds a use in the manufacture of wallpaper. The special feature of wet-ground mica in this respect is that in

TABLE 35

Production and Value of Wet- and Dry-ground Mica in the United States, 1924–1943 *

Year †	*Dry ground*			*Wet ground*			*Total ground*	
	Quantity, short tons	*Value*	*Unit*	*Quantity, short tons*	*Value*	*Unit*	*Quantity, short tons*	*Value*
1924	2,592	$101,700	$39	2,868	$331,410	$116	5,460	$433,110
1925	2,521	101,680	40	2,402	279,940	117	4,923	381,620
1926	2,375	98,290	41	2,490	206,370	83	4,865	304,660
1927	2,594	90,968	35	3,199	332,511	104	5,793	423,479
1928	2,872	95,151	33	3,317	358,458	108	6,189	453,609
1929	1,819	62,029	34	2,697	328,332	122	4,516	390,361
1930	5,956	190,635	32	1,575	161,623	103	7,531	352,258
1931	5,362	168,783	31	2,444	267,653	110	7,807	436,436
1932	5,253	126,714	24	2,452	184,126	75	7,705	310,840
1933	6,439	135,178	21	3,392	263,503	78	9,831	398,681
1934	6,824	156,046	23	2,723	247,284	91	9,547	403,330
1935	15,178	341,825	23	3,145	201,148	64	18,323	542,973
1936	20,800	457,042	22	4,785	265,374	57	25,585	722,416
1937	21,150	457,879	22	6,095	381,933	63	27,245	839,812
1938	19,757	466,959	......	7,329	457,595	......	27,086	924,554
1939	23,222	547,539	......	7,702	608,794	......	30,924	1,156,333
1940	21,809	515,930	......	6,175	500,698	......	27,984	1,016,628
1941	31,914	733,559	......	11,505	798,792	......	43,419	1,532,351
1942	36,369	805,163	......	10,610	848,195	......	46,979	1,653,358
1943	40,256	1,027,781	......	11,326	962,363	......	51,582	1,990,144

* Source: United States Tariff Commission, "The Mica Industry"; Mica Enquiry Committee Report.

† In 1930 and subsequent years, fine mica recovered from clay banks is included; in 1935 and subsequent years ground mica schist is included.

printing it produces silvery sheen effects on the paper. Until recently, the wet-grinding process had always been a well-guarded secret of the United States, as a result of which the English wallpaper manufacturers, unable to grind mica in a manner that would retain its sheen, were forced to import wet-ground mica from the United

States. They have now succeeded in inventing a process enabling them to discard their dependence on supplies from the United States. In pre-war days, nearly 3,000 short tons, representing 50 per cent of the total quantity of wet-ground mica produced, was usually absorbed annually by the wallpaper manufacturers alone.

The United States Tariff Commission reported in 1936 that 1,307 short tons of wet-ground mica were used in the manufacture of paint. Though this figure is said to reveal a very large increase over any previous records, it transpires from a communication to the United States Tariff Commission from the United States Bureau of Mines that the paint industry has since been quite active in assessing the value of mica in paints. And it was held that, if such efforts were successful, the future might afford a larger ever-increasing market for wet-ground mica.

During World War II, the consumption of ground mica for the manufacture of wallpaper was reduced considerably because of demands for war purposes as well as shortage of paper. A large portion of the ground mica had been diverted to use in paints and in coatings on tents and tarpaulins for protecting and waterproofing them.

The following remarks from the *Minerals Year Book*, 1938, are relevant in connection with this use:

> Sound reasons exist for employing large quantities of mica in almost any kind of paint. In addition to embodying the functions of rubber, it prevents it from cracking and improves adherence in much the same way as do the leaflike particles in aluminum and, more recently, metallic-lead paints.

It is also reported that ground mica of 325 mesh mixed with aluminum bronze powder has produced a paint possessing superior resistance to salt air and chemical fumes. With the close of the war, the use of ground mica as coatings on tents and tarpaulins had practically disappeared and use in wallpaper manufacturing has again been resumed. Added to this the demand for wet-ground mica from the rubber and paint industry has increased considerably, and there are good reasons to believe that in the very near future the latter will be a very potential outlet for wet-ground mica.

In the rubber industry, wet-ground mica is used as an ingredient of special rubber insulation for flexible wire connections, as an inert filler in hard rubber and certain types of rubber goods, as a lubricant in the molding and vulcanizing of motor tires, and as a dusting powder between the casing and inner tubes of motor tires to prevent friction and sticking. Small quantities of wet-ground mica are also used for lubricants such as axle grease and in a few plastic compositions.

Uses of Dry-ground Mica. The most extensive use of dry-ground mica is provided for by the manufacturers of roofing paper. Mica is spread over the somewhat sticky asphalted paper, rendering it fire-resistant to a little extent, as against falling sparks, for example, and imparting to it a glistening appearance, though the principal function of the mica is to prevent sticking when the sheet is rolled for shipment and unrolled for use.

Since talc and other substances, even fine colored gravel, are also suitably used for similar purposes, the competition of such commodities goes far toward limiting prices for dry-ground mica. This type of roofing is very common in the United States, though unpopular in European countries. Fairly large quantities of dry-ground mica of a very coarse mesh are used as artificial snow by the moving-picture producers and as Christmas-tree decorations.

Considerable quantities of coarse-ground mica are used for lagging for pipes and boilers. Its other uses are for welding-rod coatings, pipe-line enamel, house insulation, annealing, textiles, oil-well drilling, welding, concrete and foundry facing, ornamentation of concrete, tile, and stucco surfaces, and inert filling in gramophone records and as an ingredient in the manufacture of explosives and a base in cleanser compounds, lithographing, etc.

The only important function of ground mica as insulation is in the manufacture of Mycalex, in which it is the chief ingredient. Mycalex is made by melting lead borate or soft glass with 60-mesh mica in about the proportion of one of glass and two of mica, by weight. While the cost, pound for pound, of Mycalex is greater than that of certain other insulating materials of the porcelain or glass type, it admits of simpler, smaller, and less costly parts and has better electrical and mechanical properties for such things as antenna insulators, Pliotron tube bases, brush holders, and insulated pipe joints. Miscellaneous uses for ground mica, some of which may include both wet- and dry-ground material, are for lubricants, annealing, concrete and foundry facings, pipe-line enamel, and plastic specialties.

Table 36 supplies the total sales of ground mica in the United States during 1926-1937, with details of consumption by different industries.

TABLE 36

SALES OF GROUND MICA IN THE UNITED STATES, 1926–1937 *

Year †	*Roofing*	*Wallpaper*	*Rubber*	*Miscellaneous* ‡	*Total*
1926	609	1,260	1,655	1,342	4,866
1927	1,293	1,884	1,588	1,028	5,793
1928	1,294	1,614	1,933	1,348	6,189
1929	603	1,614	1,316	983	4,516
1930	4,826	970	506	1,229	7,531
1931	3,592	2,665	1,029	521	7,807
1932	4,383	1,752	668	902	7,705
1933	5,756	2,340	963	772	9,831
1934	6,595	1,778	858	317	9,547
1935	14,403	2,051	768	1,101	18,323
1936	20,279	2,869	516	1,921	25,585
1937	21,636	2,623	1,413	1,573	27,245

* Source: United States Tariff Commission, "The Mica Industry," p. 110.

† Mica from clay washing first included in statistics for 1930.

‡ Molded insulation, surfacing asphalt shingles, paints, Christmas-tree snow, lubricants, annealing, concrete and foundry facing, pipe-line enamel, plastic specialties, etc.

WASTE OR SCRAP MICA

Interesting information is contained in the United States Tariff Commission report in respect to the domestic production of mica waste that largely feeds the mica-grinding industry of the United

States. Such production of waste or scrap mica is derived from different sources, as described in the following paragraphs.

From Clay Deposits. In North Carolina, recovery of mica, practically in powdered form, as a by-product in the working of clay deposits has grown to a good size and is a useful industry. Clay deposits—usually decomposed granite or feldspar—contain mica either as a principal constituent or as an associate.

Such mica contents are separated from the clay in the process of refining it. Moreover, through the recovery of mica during the washing process of the clay, the clay is made purer and the cost of such purification is more than compensated by the value of mica obtained. The mica thus recovered from such clay deposits, being already in a more or less pulverized state, is used without any further grinding, largely by the roofing manufacturers, though the price at which they offer the product is somewhat lower than that of manufactured ground mica.

From Mica Schists. In California, Arizona, Georgia, and North Carolina mica is recovered from schists, much in the same manner as from clay. Schists of the muscovite or sericite type with very high mica contents are used only for this purpose, and mica is extracted by first crushing such schists and then subjecting them to some concentration method. The product thus obtained is sold, like that recovered from clay, in several sizes of meshes and is absorbed by the roofing manufacturers.

From Mining (exclusively for scrap). In North Carolina and in one or two Southern states and in Colorado, there are several mica deposits producing mica that can be used only as scrap for grinding purposes.

From Factory Scrap. In the various fabricating plants, the production of waste or scrap represents at least 50 per cent of the total quantity of sheet mica used. Such scrap, being mostly pure or, to be precise, purer than mica waste otherwise obtained, commands a better price and is used chiefly for wet grinding.

The collective production of mica scrap from all the sources alluded to above is large enough for the United States to supply the demand to a very considerable extent, though the rapidly increasing demand for dry-ground mica in particular requires importation of foreign scrap to the United States, especially from India and Canada.

Table 37 shows total production of scrap in the United States from 1924 to 1937 and Table 38 shows the quantities of waste mica imported into the United States from various countries during 1931-1937 and the prices paid to the respective countries.

TABLE 37

SALES OF MICA WASTE AND SCRAP BY UNITED STATES PRODUCERS, 1924–1937 *

Year †	*Quantity, short tons*	*Value*	*Unit value*
1924	4,709	$ 87,242	$18.53
1925	9,695	173,537	17.90
1926	7,043	136,643	19.40
1927	6,280	110,139	17.54
1928	7,760	132,422	17.07
1929	6,253	117,901	18.85
1930	6,732	109,100	16.21
1931	6,621	99,415	15.01
1932	7,040	83,777	11.90
1933	8,751	98,159	11.22
1934	7,719	99,791	12.93
1935	18,852	243,951	12.94
1936	20,955	260,594	12.43
1937	25,196	354,737	14.08

* Source: United States Tariff Commission, "The Mica Industry," p. 114.

† In 1935 and subsequent years, ground schist is included; in 1930 and subsequent years, fine mica recovered from clay banks is included.

From the Indian point of view, however, the export of scrap does not lead to a lucrative end, though, as shown in Table 39, India exports considerable quantities of waste mica, mostly to the United States and a comparatively smaller quantity to the United

TABLE 38

MICA WASTE AND SCRAP VALUED AT NOT OVER 5 CENTS PER POUND: UNITED STATES IMPORTS FOR CONSUMPTION FROM PRINCIPAL SOURCES *

Imported from	1931	1932	1933	1934	1935	1936	1937
			Quantity in short tons				
British India	222	336	236	1,613	1,667	2,709	4,718
Canada	1,378	374	988	860	696	1,184	1,199
U.S.S.R.	None	None	166	807	667	None	None
Union of South Africa	464	117	229	225	None	None	797
Other countries	†	533	None	None	None	None	7
Total	2,065	1,360	1,619	3,505	3,030	3,893	6,722
			Value				
British India	$ 2,219	$ 2,107	$ 2,659	$14,138	$ 9,204	$11,023	$18,110
Canada	14,660	3,209	8,682	7,803	6,191	11,643	11,971
U.S.S.R.	None	None	841	4,313	3,703	None	None
Union of South Africa	5,143	889	1,710	1,620	None	None	5,730
Other countries	35	5,703	None	None	None	None	544
Total	$22,057	$11,908	$13,892	$27,874	$19,098	$22,666	$36,355
			Value per short ton				
British India	$10.00	$ 6.27	$11.27	$8.76	$5.52	$4.07	$3.84
Canada	10.64	8.58	8.79	9.07	8.90	9.83	9.99
U.S.S.R.	....	....	5.07	5.34	5.55		
Union of South Africa	11.08	7.60	7.47	7.20	....	....	7.19
Other countries	35.00	10.70	....	....	....	....	7.77
Average	$10.68	$ 8.76	$ 8.58	$7.95	$6.30	$5.82	$5.41
			Per cent of total quantity				
British India	10.8	24.7	14.6	46.1	55.0	69.6	70.1
Canada	66.7	27.5	61.0	24.5	23.0	30.4	17.7
U.S.S.R.	....	....	10.3	23.0	22.0		
Union of South Africa	22.5	8.6	14.1	6.4	....	....	1.1
Other countries	‡	39.2	....	....	....	....	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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* Source: United States Tariff Commission, "The Mica Industry," p. 117.

† Provided for under Par. 208(*g*) of the Tariff Act of 1930. This same paragraph also provides that mica waste and scrap valued at more than 5 cents per pound shall be dutiable as unmanufactured mica, Par. 208(*a*), but so far as is known, there have never been any such imports.

‡ Less than 0.1 per cent.

Kingdom. Table 40, which gives the export of mica waste only to the United States, shows this clearly.

TABLE 39

EXPORTS FROM THE PORT OF CALCUTTA, 1935–1943 *

Year	*Exports of Scrap, cwt.*
1935	36,755
1936	43,652
1937	57,173
1938	70,150
1939	38,562
1940	36,841
1941	5,036
1942	18,457
1943	45,468

* Compiled from J. Banerjee's Export List.

TABLE 40

MICA WASTE AND SCRAP IMPORTED INTO THE UNITED STATES FROM BRITISH INDIA, 1931–1940 *

Year	*Quantity, short tons*	*Value*
1931	222	$ 2,219
1932	336	2,107
1933	236	2,659
1934	1,613	14,138
1935	1,667	9,204
1936	2,709	11,023
1937	4,718	18,110
1938	3,170	17,331
1939	Not available	
1940	2,162	13,921

* Mica Enquiry Committee Report, p. 54.

In comparison with the total quantity produced, the quantity exported can be regarded as of little significance, for most of it is left at the pit-mouth dumps, heaps, etc., in the mining areas situated at distances of between 20 to 70 miles from the nearest railway station. Hence, all that which is produced in the factories in towns with railway communications and other facilities is shipped. In view of the low price usually offered by foreign consumers, the utilization of the mines' dump of scrap mica is prohibited by the sole factor of exorbitant transport charges. It is not only the distance, but the roughness of the mines' roads as well, that contributes largely to the impracticability of the proposition; and the foreign demand also was never heavy enough to warrant exploiting these dumps.

The export of mica scrap, however, does not offer a very alluring proposition to an exporter, for by far the major part of the value obtained is neutralized by the cost of drying, sieving, packing, gunny bags, railway freight, and other charges, thus leaving the exporter with a very meager profit.

Detailed information about the uses of mica in modern electronic developments like the Geiger counter, radar, and television are not yet in my possession. In short, I may say that television has considerably broadened the uses of bridge mica and condenser films, and radar that of sheet mica wrappers in lengths up to 12 in. The Geiger counter demands something unique in very thin mica films, split to an unbelievable thinness of up to $\frac{1}{8,000}$ in., absolutely free from scratches or even finger prints, because the thinner the films, the more complete is the passage of radioactive rays through the mica used in the windows of this instrument.

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CHAPTER 12

A Study of Descriptive and Analytical Statistics of Mica

Statistics available for Bihar mica are limited only to the total production in terms of S.D.B. and export. Though the figures of export are not available specifically for Bihar mica, it can safely be assumed that whatever mica is exported from the port of Calcutta represents the total export of Bihar and Rajputana mica. Hence for the purpose of comparison between production and export the production of Rajputana will be included because practically the entire production of Rajputana is processed and shipped by Bihar. The figures of export can be considered accurate, but those relating to production cannot possibly be relied upon.

Dr. J. A. Dunn has expressed his views about production statistics as follows: *

> It might be expected that the combined production from Bihar and Rajputana [Table 41] should more or less compare with the exports of block and splittings from Calcutta. Actually the exports are between 25 and 50 per cent in excess of this combined production, except for 1938, when the reported combined production from Rajputana and Calcutta was 20,000 cwt. in excess of the exports from Calcutta. Allowing for these abnormal 1938 figures, it is apparent that there is large annual excess of exports over production, and this discrepancy is not accounted for by mounting stocks. It is partly explained by (*a*) export of stolen mica, which does not appear in reported production; (*b*) export of legitimate mica from small concerns, which does not appear in recorded returns; (*c*) export of splittings made from dump cut block, *i.e.,* from mica obtained by turning over old dumps; and (*d*) exported mica which has been imported from other countries for sorting and re-export as splittings (such as imports recorded, which have annually averaged 268 cwt. of block and 538 cwt. of splittings for the years 1934-1938).

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* Geological Survey of India, *Bulletin* 10, "Mica."

The amount of stolen mica has been exaggerated in the past. It is very small compared with the total production, but its value is great because it is mainly of the better qualities.

There is a considerable controversy about the source and methods of collecting these statistics by the government. Though they are collected from the office of the Chief Inspector of Mines from the annual returns submitted by the various mining concerns in the Bihar mica field, some believe that they are collected from the cess (tax) paid to the government on production. But calculation of the total production of Bihar from the cess collected by government on such production is absurd, for in different districts cess is collected on different bases. In the Hazaribagh district the cess is charged at a fixed rate per maund of S.D.B. produced or a maund of crude mica sold. The crude mica in stock is not taken into consideration at all, while in Gaya, Monghyr, and Bhagalpur districts the collection of the same is based on an entirely different principle. In these districts production figures have nothing to do with the paying of cess. The entire cess is charged on the total profit made at a certain rate per rupee. The impossibility of calculating the total production of Bihar upon such various figures of cess needs no further comment.

In studying the collection of production figures from the Mines Department, it must be remembered that annual returns are submitted only for the reported mines. Thus the total figure compiled refers only to the production obtained from such reported mines. In addition to the production from the reported mines, considerable quantities of mica are also obtained from upperchella pits (prospecting pits), most of which are not reported. One might argue that according to government regulations such upperchella pits should have been reported. But considering the vast number of such pits, it is not possible for the industry to report to the Chief Inspector of Mines all the small potholes that must be made in the mica pegmatites for the purpose of prospecting. Nor is it practicable for the Mines Department to maintain the records of thousands of such small pits in their office. In view of the practical difficulties involved, a very strict enforcement of some of the mine regulations has, of necessity, to be ignored in the case of mica mines. The following is what Dr. Dunn says about this in the previously mentioned bulletin on mica.

> Probably 25 per cent of the mica of the Bihar belt is produced from surface workings, known locally as "upperchella" workings, which are usually understood to extend down to only 20 ft.; actually some so-called "upperchella" workings have been extended to much greater depths. Inspections under the mines act are usually restricted to the smaller number of deeper mines.

Apart from the production from the upperchella pits, which is estimated to be about 25 per cent of the actual production from the mines, the recovery of smaller grade splitting-quality mica like Nos. 6 and 7, both from the mine and the factory dumps, contributes a substantial portion to the total production of Bihar. Production from the dumps, however, in most cases is not included in the annual returns to the Mines Department. Consequently it cannot but be concluded that the reported production is not accurate, and with no exaggeration one can safely say that the discrepancy is at least 35 to 40 per cent on the minus side.

TABLE 41

SOME STATISTICS ON BIHAR AND RAJPUTANA MICA PRODUCTION, CWT., 1931–1939

	1931	1932	1933	1934	1935	1936	1937	1938	1939
Total quantity exported from Calcutta	33,056	31,205	35,816	55,702	76,114	99,491	134,425	79,618	106,991
Total production of Bihar	31,720	24,097	32,674	45,979	50,821	71,738	85,978	84,235	86,765
Total production of Rajputana	285	247	396	538	544	2,949	3,477	16,318	29,288
Total production of Bihar and Rajputana	32,005	24,344	33,070	46,517	51,365	74,687	89,455	100,553	116,053

Table 41 gives the total yearly figures of Bihar and Rajputana production and export of mica from the port of Calcutta, etc., and Tables 42 and 43 give the details of exports of mica from India and its value. Table 43 has been taken from the "Hand Book of Mica" by Mr. R. R. Choudhury, while Table 42 has been taken from *Bulletin* 10, "Mica," published by the Geological Survey of India. The figures of export of both blocks and splittings as compiled by these two authorities differ considerably from each other for reasons unknown to the author. However, Table 43 will give an idea of the gradual growth of the splittings industry in India.

TABLE 42

PRODUCTION AND EXPORTS OF MICA FROM CALCUTTA, CWT.

	1934	1935	1936	1937	1938	1939
Production of S.D.B. of Bihar	45,979	50,821	71,738	85,978	84,235	86,765
Production of S.D.B. of Rajputana	538	544	2,949	3,477	16,318	29,288
Total production	46,517	51,365	74,687	89,455	100,553	116,053
Total export of blocks	14,833	16,653	18,669	21,323	14,385	24,646
Total export of splittings	40,869	59,461	80,822	113,102	65,233	82,345
Total export of blocks and splittings	55,702	76,114	99,491	134,425	79,618	106,991
Percentage of block mica exported on the production of Bihar and Rajputana	32	32	25	24	14	21
Percentage of splittings exported on the production of Bihar and Rajputana	88	116	108	128	65	71

Besides these, no other statistics are available. This poverty of statistical information makes it impossible at times to get a true picture of affairs when some controversy arises in connection with vital issues that involve use of statistics like the one in existence today, *viz.*, mica piracy. To enable correct findings for the decision of such issues, at least the following details are essential:

1. Percentage of salable blocks or sheet mica in the average production of S.D.B.
2. Percentages of each grade in the same.
3. Percentages of each quality in an average sample of each of the various grades of mixed-quality S.D.B.

TABLE 43

DISTRIBUTION OF EXPORTS OF MICA FROM INDIA, 1921–1937

Year	*Total Export*											
	Block		*Splittings*		*Mica blocks and splittings*		*United Kingdom, cwt.*	*United States, cwt.*	*Germany*	*Japan*	*France*	*Others*
	Cwt.	*Rs.*	*Cwt.*	*Rs.*	*Cwt.*	*Rs.*						
1921	4,011	18,42,469	17,651	32,15,314	30,944	63,94,113	19,376	8,304	1,469	....	......	1,795
1922	9,001	17,80,494	34,144	40,04,751	43,145	97,85,245	15,905	18,234	5,752	....	......	3,254
1923	12,401	16,46,944	70,895	64,29,578	83,296	80,76,522	20,213	52,886	5,822	....	......	4,375
1924	15,258	28,81,623	54,837	65,67,545	70,095	94,49,168	27,114	31,923	4,528	....	......	5,301
1925	14,952	33,21,061	84,747	73,12,062	99,699	1,06,33,123	36,118	39,928	16,395	....	1,179	6,072
1926	15,882	34,04,399	74,125	75,95,678	89,941	1,10,00,077	31,618	47,038	4,984	....	1,186	4,967
1927	14,259	32,82,248	63,229	50,81,724	77,488	92,63,972	38,298	18,410	11,014	....	1,340	5,890
1928	12,413	30,81,724	82,066	62,73,407	95,479	93,54,946	42,556	23,968	15,286	....	3,876	9,686
1929	17,799	41,40,349	98,276	63,66,485	116,075	1,05,06,834	40,132	48,348	10,190	....	3,983	9,899
1930	14,824	28,61,021	68,085	47,26,710	82,909	75,87,731	38,478	23,982	7,788	....	7,506	7,611
1931	8,276	14,95,203	44,698	26,53,565	52,966	41,48,768	22,891	12,378	3,831	....	5,050	9,056
1932	6,693	13,82,135	40,328	19,66,808	47,021	33,48,943	22,389	11,264	5,013	....	4,810	7,567
1933	15,702	24,29,357	40,945	15,62,676	57,717	40,92,033	22,505	19,812	6,161	....	788	7,102
1934	20,617	35,20,930	72,301	25,09,595	92,918	69,30,525	29,606	39,517	10,013	....	1,067	12,019
1935	23,774	43,34,680	118,040	37,00,001	141,814	80,34,681	37,448	69,397	12,813	8,274	1,763	10,169
1936	27,235	45,72,240	150,429	46,04,271	177,668	91,76,511	43,049	93,080	19,053	9,125	3,713	5,764
1937	30,003	57,47,478	267,340	84,12,558	297,343	1,43,60,036	65,784	185,143	18,854	11,815	7,743	13,049

4. Percentage of each quality of each grade in the average production of S.D.B.

5. Relative importance of each grade and quality in an average bulk of S.D.B. or a particular grade in terms both of quantity and of value.

An accurate estimate of the above details is impracticable, but some approximate figures may be made available for an average bulk sample of the production of the Bihar mica field in general.

Since no statistics are available, I am including the results I have obtained by an analysis of a considerable quantity of mica.

Table 44 gives the percentage of each grade in the bulk of S.D.B. produced by one of the principal concerns of Bihar separately for each of the 4 years' total production and the average of such percentages over the total production for the same period.

TABLE 44

APPROXIMATE PERCENTAGE OF EACH GRADE IN THE AVERAGE PRODUCTION OF BIHAR S.D.B. (BIMA)

Year	*Special and up, per cent*	*No. 1, per cent*	*No. 2, per cent*	*No. 3, per cent*	*No. 4, per cent*	*No. 5, per cent*	*No. 5½, per cent*	*Nos. 6 and 7, per cent*
I	0.165	0.476	1.68	2.61	6.20	12.32	6.99	69.53
II	0.181	0.472	1.51	2.23	5.59	11.43	6.85	71.73
III	0.172	0.402	1.24	1.92	4.68	9.92	8.37	73.22
IV	0.140	0.471	1.82	2.94	6.85	11.64	8.81	67.33
Average in four years' total production	0.166	0.450	1.53	2.38	5.72	11.22	7.79	70.76

Since the percentages have been deduced from over 60,000 cwt. of S.D.B., from at least a hundred mines both large and small, scattered over a large part of the Bihar mica belt, these may be assumed as fairly representative figures for the average production of Bihar in the discussion that follows.

Now let us proceed with the analysis of an average sample of each grade of mixed S.D.B. mica and determine the percentage of each of the various commercial qualities present (Tables 45 to 51). An average sample of 1,000 lb. of each of these grades was collected from a number of mines in different localities of the Bihar mica belt and a quality sorting was made according to the Joint Mica Mission standard, and the value of each of the popular grades was calculated on the basis of the Joint Mica Mission basic prices for the standard-quality blocks and the value that would be recovered by manufacturing condenser films and splittings from the condenser chillas and splitting-quality chillas and blocks. The Joint Mica Mission did not purchase stained-quality thick chillas or thin blocks, which always found a market in pre-war days. Hence reasonable prices have been assumed for calculating the value of the quantities of such thin blocks obtained at the time of this qualitative sorting. Referring to Table 51, I invite the reader's attention to an item described as 1-in. circle. This means pieces selected to punch circular disks of 1 in. diameter. The Joint Mica Mission did not buy this particular grade, though under normal conditions it always finds markets, especially in the United States, at a slightly lower price than that of regular-size No. 6 stained-quality mica. Therefore a reasonable price has been assumed for this grade as well as for the purpose of calculation. The results are shown in Tables 45 to 51, and the value of 100 lb. of each grade of S.D.B. thus calculated is given in Table 52.

Figures from the last columns of Tables 45 to 51 have been tabulated in Table 53 to show the percentage of each quality of different grades that may be expected in the average production of bima blocks.

Adding up figures from Table 53 representing the percentage of salable block, we obtain the total percentage of mica salable in block or sheet form in the average production of Bihar S.D.B., which comes to about 34 per cent. This figure varies considerably with the demand for No. 5 and down stained-quality mica. Gen-

TABLE 45

Analytical Results of 1,000 Lb. of No. 1 S.D.B.

(The approximate percentage of No. 1 S.D.B. in the average production of Bihar S.D.B. [bima] = 0.450)

Value expressed in Rs. (rupees), a. (annas), p. (pies). 1 Rupee = 30.33 U.S. cents, 1 anna = less than 2 cents, 1 pie = 1/12 of 2 cents

(Calculated in terms of rupees on the basic prices of the J.M.M. fixed in 1942)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 1 S.D.B.*	*Percentage of each quality in an average production of bima S.D.B.*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 1 clear & S.S.	3	2	28	8	0	89	1	0	0.31	0.0014
No. 1 fair stained	12	8	19	0	0	237	8	0	1.25	0.0056
No. 1 good stained	88	12	14	0	0	1,242	8	0	8.88	0.0399
No. 1 stained	365	0	11	8	0	4,197	8	0	36.50	0.1643
No. 1 heavily stained	177	8	9	0	0	1,597	8	0	17.75	0.0799
No. 1 densely stained	37	8	7	4	0	271	14	0	3.75	0.0169
No. 2 good stained	18	12	12	0	0	225	0	0	1.88	0.0084
No. 2 stained	18	12	9	0	0	168	12	0	1.88	0.0084
No. 2 heavily stained	6	4	6	8	0	40	10	0	0.62	0.0028
No. 3 stained	6	4	7	0	0	43	12	0	0.62	0.0028
No. 2 condenser chillas	18	12	10	4	0	192	3	0	1.88	0.0084
No. 1 thick chillas or thin blocks	43	12	9	8	0	415	10	0	4.38	0.0197
No. 2 thick chillas or thin blocks	6	4	7	2	0	44	8	6	0.62	0.0028
No. 3 thick chillas or thin blocks	6	4	5	4	0	32	13	0	0.62	0.0028
No. 1, 2, 3 mixed thin chillas	87	8	2	8	0	218	12	0	8.75	0.0394
Cuttings	103	2	....			....			10.31	0.0464
Total	1,000	0	....			9,017	15	6	100.00	

TABLE 46

ANALYTICAL RESULTS OF 1,000 LB. OF NO. 2 S.D.B.

(The approximate percentage of No. 2 S.D.B. in the average production of Bihar S.D.B. [bima] = 1.532)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 2 S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 2 clear & S.S.	3	2	24	0	0	75	0	0	0.31	0.0048
No. 2 fair stained	12	8	15	0	0	187	8	0	1.25	0.0192
No. 2 good stained........	125	0	12	0	0	1,500	0	0	12.50	0.1915
No. 2 stained....	357	8	9	0	0	3,217	8	0	35.75	0.5477
No. 2 heavily stained........	161	4	6	8	0	1,048	2	0	16.12	0.2470
No. 2 densely stained........	25	0	5	4	0	131	4	0	2.50	0.0383
No. 3 good stained........	18	12	9	8	0	178	2	0	1.88	0.0288
No. 3 stained....	12	8	7	0	0	87	8	0	1.25	0.0192
No. 3 heavily stained........	3	2	4	10	0	14	7	3	0.31	0.0048
No. 4 stained....	6	4	5	8	0	34	6	0	0.63	0.0097
No. 3 condenser chillas........	18	12	10	4	0	192	3	0	1.88	0.0288
No. 2 thick chillas or thin blocks........	43	12	7	2	0	311	11	6	4.37	0.0671
No. 3 thick chillas or thin blocks........	6	4	5	4	0	32	13	0	0.63	0.0097
No. 4 book block	6	4	4	0	0	25	0	0	0.63	0.0097
No. 2, 3, 4, mixed thin chillas....	81	4	2	8	0	203	2	0	8.12	0.1244
No. 5 thin chillas	6	4	1	4	0	7	13	0	0.62	0.0095
Cuttings........	112	8	....			....			11.25	0.1724
Total.........	1,000	0	....			7,246	7	9	100.00	

TABLE 47

ANALYTICAL RESULTS OF 1,000 LB. OF No. 3 S.D.B.

(The approximate percentage of No. 3 S.D.B. in the average production of Bihar S.D.B. [bima] = 2.377)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 3 S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 3 clear & S.S.	6	4	21	0	0	131	4	0	0.63	0.0149
No. 3 fair stained	12	8	12	8	0	156	4	0	1.25	0.0297
No. 3 good stained	126	4	9	8	0	1,199	6	0	12.62	0.2999
No. 3 stained	355	8	7	0	0	2,488	8	0	35.55	0.8450
No. 3 heavily stained	162	4	4	10	0	750	6	6	16.23	0.3858
No. 3 densely stained	44	0	3	8	0	154	0	0	4.40	0.1046
No. 4 fair stained	3	2	10	8	0	32	13	0	0.31	0.0074
No. 4 good stained	15	10	7	8	0	117	3	0	1.56	0.0371
No. 4 stained	20	0	5	8	0	110	0	0	2.00	0.0475
No. 4 heavily stained	12	8	3	4	0	40	10	0	1.25	0.0297
No. 3 condenser chillas	12	8	10	4	0	128	2	0	1.25	0.0297
No. 4 condenser chillas	4	4	9	6	0	39	13	6	0.42	0.0101
No. 3 thick chillas or thin blocks	29	0	5	4	0	152	4	0	3.90	0.0927
No. 4 book block	6	4	4	0	0	25	0	0	0.63	0.0149
No. 3 thin splitting chillas	68	4	2	8	0	170	10	0	6.83	0.1623
No. 4 thin splitting chillas	12	8	2	8	0	31	4	0	1.25	0.0297
No. 5 thin splitting chillas	3	0	1	4	0	3	12	0	0.30	0.0071
Cuttings	96	4	...			...			9.62	0.2287
Total	1,000	0	...			5,731	4	0	100.00	

TABLE 48

ANALYTICAL RESULTS OF 1,000 LB. OF NO. 4 S.D.B.

(The approximate percentage of No. 4 S.D.B. in the average production of Bihar S.D.B. [bima] = 5.716)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 4 S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 4 clear & S.S.	6	4	17	4	0	107	13	0	0.62	0.0354
No. 4 fair stained	43	8	10	8	0	456	12	0	4.35	0.2486
No. 4 good stained........	155	14	7	8	0	1,169	1	0	15.59	0.8911
No. 4 stained....	327	8	5	8	0	1,801	4	0	32.75	1.8720
No. 4 heavily stained........	87	8	3	4	0	284	6	0	8.75	0.5002
No. 4 densely stained........	8	6	2	0	0	16	12	0	0.84	0.0480
No. 5 fair stained	1	8	6	8	0	9	12	0	0.15	0.0086
No. 5 good stained........	6	4	4	8	0	28	2	0	0.62	0.0354
No. 5 stained....	7	12	3	0	0	23	4	0	0.77	0.0446
No. 5½ stained..	1	8	2	0	0	3	0	0	0.15	0.0086
No. 6 stained....	4	10	0	14	0	4	0	9	0.46	0.0263
No. 4 condenser chillas........	30	10	9	6	0	287	1	9	3.06	0.1749
No. 5 condenser chillas........	3	2	5	10	0	17	9	3	0.31	0.0177
No. 4 book block	137	8	4	0	0	550	0	0	13.75	0.7860
No. 5 book block	6	4	2	8	0	15	10	0	0.62	0.0354
No. 5½ book block.........	1	8	1	6	0	2	1	0	0.15	0.0086
No. 4 thin splitting chillas....	47	8	2	8	0	118	12	0	4.75	0.2715
No. 5 thin splitting chillas....	12	8	1	4	0	15	10	0	1.25	0.0715
No. 5½ thin splitting chillas	3	2	0	14	0	2	11	9	0.31	0.0177
No. 6 first-quality splittings, blocks........	12	8	0	9	9	7	9	10	1.25	0.0715
Cuttings........	93	12	....			....			9.37	0.5361
Total.........	1,000	0	....			4,921	4	4	100.00	

TABLE 49

Analytical Results of 1,000 Lb. of No. 5 S.D.B.

(The approximate percentage of No. 5 S.D.B. in the average production of Bihar S.D.B. [bima] = 11.218)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 5 S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 5 clear & S.S.	9	6	12	0	0	112	8	0	0.94	0.1054
No. 5 fair stained	49	12	6	8	0	323	6	0	4.97	0.5587
No. 5 good stained........	152	8	4	8	0	686	4	0	15.25	1.7107
No. 5 stained....	209	0	3	0	0	627	0	0	20.90	2.3446
No. 5 heavily stained........	46	2	1	14	0	86	7	9	4.61	0.5171
No. 5½ fair stained........	3	2	4	12	0	14	13	6	0.31	0.0348
No. 5½ good stained........	6	4	3	8	0	21	14	0	0.63	0.0707
No. 5½ stained..	25	0	2	0	0	50	0	0	2.50	0.2805
No. 6 clear & S.S.	1	8	3	4	0	4	14	0	0.15	0.0168
No. 6 fair stained	3	2	2	0	0	6	4	0	0.31	0.0348
No. 6 good stained........	9	6	1	8	0	14	1	0	0.94	0.1054
No. 6 stained....	6	4	0	14	0	5	7	6	0.63	0.0707
No. 5 condenser chillas........	32	12	5	10	0	184	3	6	3.27	0.3680
No. 5½ condenser chillas.....	6	4	3	12	0	23	7	0	0.63	0.0707
No. 5 book block	212	0	2	8	0	530	0	0	21.20	2.3782
No. 5½ book block.........	12	0	1	6	0	16	8	0	1.20	0.1346
No. 5 loose splitting chillas....	60	0	1	4	0	75	0	0	6.00	0.6731
No. 5½ loose splitting chillas	12	8	0	14	0	10	15	0	1.25	0.1402
No. 6 first-quality loose splittings blocks........	25	0	0	9	9	15	3	9	2.50	0.2855
Cuttings........	118	2	....			....			11.81	1.3248
Total.........	1,000	0	....			2,808	5	0	100.00	

TABLE 50

ANALYTICAL RESULTS OF 1,000 LB. OF NO. 5½ S.D.B.

(The approximate percentage of No. 5½ S.D.B. in the average production of Bihar S.D.B. [bima] = 7.788)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 5½ S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 5½ clear & S.S.	9	6	6	10	0	62	1	9	0.94	0.0732
No. 5½ fair stained	52	8	4	12	0	249	6	0	5.25	0.4089
No. 5½ good stained	137	8	3	8	0	481	4	0	13.75	1.0709
No. 5½ stained	193	12	2	0	0	387	8	0	19.37	1.5093
No. 5½ heavily stained	40	14	1	4	0	51	1	6	4.09	0.3185
No. 6 fair stained	3	4	2	0	0	6	8	0	0.33	0.0257
No. 6 good stained	15	8	1	8	0	23	4	0	1.55	0.1207
No. 6 stained	37	8	0	14	0	32	13	0	3.75	0.2921
No. 5½ condenser chillas	30	0	3	12	0	112	8	0	3.00	0.2336
No. 5½ book block	235	12	1	6	0	324	2	6	23.58	1.8364
No. 5½ loose splittings, chillas	62	8	0	14	0	54	11	0	6.25	0.4868
No. 6 first-quality loose splittings, blocks	70	0	0	9	9	42	10	6	7.00	0.5452
Cuttings	111	8	....			....			11.15	0.8684
Total	1,000	0	....			1,827	14	3	100.00	

TABLE 51

ANALYTICAL RESULTS OF 1,000 LB. OF NO. 6 S.D.B.

(The approximate percentage of No. 6 S.D.B. in the average production of Bihar S.D.B. [bima] = 70.752)

	Weight		*Rate*			*Value*			*Percentage of each quality in No. 6 S.D.B.*	*Percentage of each quality in an average production of bima*
	lb.	*oz.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*		
No. 6 clear & S.S.	3	2	3	4	0	10	2	6	0.31	0.2193
No. 6 fair stained	21	0	2	0	0	42	0	0	2.10	1.4858
No .6 good stained........	47	8	1	8	0	71	4	0	4.75	3.3607
No. 6 stained....	100	4	0	14	0	87	11	6	10.03	7.0964
No. 6 1-in. circle.	53	2	0	11	9	39	0	3	5.31	3.7559
No. 6 first-quality loose splittings, blocks........	234	6	0	9	9	142	13	0	23.44	16.5842
No. 6 second- and third-quality loose splittings, blocks........	375	0	0	2	0	46	14	0	37.50	26.5320
Cuttings........	165	10	....			....			16.56	11.7165
Total.........	1,000	0	....			439	13	3	100.00	

TABLE 52

VALUE OF 100 LB. OF VARIOUS GRADES OF S.D.B. MICA ACCORDING TO 1942 RULING PRICES

Grade	*Value,* *Rs.*	*a.*	*p.*
No. 1	901	11	0
No. 2	724	10	0
No. 3	573	2	0
No. 4	492	2	0
No. 5	280	13	0
No. 5½	182	12	0
No. 6	43	14	0

TABLE 53

PERCENTAGE OF EACH QUALITY OF DIFFERENT GRADES IN AN AVERAGE BULK OF S.D.B. OF BIHAR

Grading	*Clear & S.S., per cent*	*Fair stained, per cent*	*Good stained, per cent*	*Stained, per cent*	*Heavily stained, per cent*	*Densely stained, per cent*	*Condenser chillas, per cent*	*Thick chillas or thin blocks, per cent*	*Thin splitting chillas, per cent*	*Book block, per cent*	*Splitting block, per cent*	*Cuttings, per cent*
No. 1..........	0.0014	0.0056	0.0399	0.1643	0.0799	0.0169	....	0.0197				
No. 2..........	0.0048	0.0192	0.1999	0.5561	0.2498	0.0383	0.0084	0.0699				
No. 3..........	0.0149	0.0297	0.3287	0.8670	0.3906	0.1046	0.0585	0.1052				
No. 4..........	0.0354	0.2560	0.9282	1.9292	0.5299	0.0480	0.1850	....	0.6273	0.8106		
No. 5..........	0.1054	0.5673	1.7461	2.3892	0.5171	....	0.3857	....	0.7789	2.4136		
No. 5½........	0.0732	0.4437	1.1416	1.7984	0.3185	....	0.3043	....	0.6270	1.9796		
No. 6..........	0.2361	1.5463	3.5868	7.4855	....	....	....	....	....	....	44.0184	
No. 7..........	....	....	....	3.7559 (1-in. circle)								
Total........	0.4712	2.8678	7.9712	18.9456	2.0858	0.2078	0.9419	0.1948	2.3332	5.2038	44.0184	14.7988

erally there is no appreciable demand for such mica in normal times, and about 50 per cent of the bulk of these smaller grades of stained-quality mica (about 90 per cent of Nos. 5 and 5½ and 25 per cent of No. 6) is used for manufacturing book-packed splittings and the remaining 50 per cent may be sold as stained-quality blocks. Hence let us shift 50 per cent of the total bulk of 5, 5½, and 6 stained blocks to book-quality blocks for affording circumstantial correction to the above percentage. Referring to Table 53, the percentage of such stained block is about 11.7 per cent. So 50 per cent of 11.7 per cent equals 5.8 or say 6 per cent. Therefore 34 per cent minus 6 per cent equals 28 per cent. Thus about 28 per cent of the average bulk of Bihar S.D.B. should be regarded as marketable block-quality mica.

On the basis of these percentages and the prices taken into consideration in Tables 45 to 51, the values of the quantities of each quality available in 10,000 lb. of Bihar S.D.B. have been calculated and tabulated in Table 54.

A study of Table 54 brings out the relative importance of each quality of different grade, of a particular quality of all grades, and of a particular grade of all qualities in the S.D.B. production of Bihar in terms of value. For the relative importance in terms of quantity, I refer to Table 53.

Referring to Table 54, the total value of 10,000 lb. of S.D.B. is Rs.13,392/–. Therefore the price of 100 lb. of average Bihar S.D.B. is Rs.134/–. Assuming recovery of 20 per cent of S.D.B. from the crude, which is in fact the general average, the value of 100 lb. of average crude mica produced by the mica field of Bihar was about Rs.29/10/– in 1942. Considering the cost of production under war conditions, the recovery of the above value allowed a very poor profit to the mica trade. The proportion in which the various grades and qualities occur in an average bulk of Bihar S.D.B may be assumed to remain fairly constant, but that their relative value varies widely with the state of the demand for each. When issues are raised in connection with increase in prices of mica, different statements are made by different people, and these are so categorical that one is led to think that mica, like all other minerals or metals, is one type of material.

TABLE 54

THE VALUE OF EACH QUALITY OF DIFFERENT GRADES IN AN AVERAGE BULK OF 10,000 LB. OF S.D.B. IN BIHAR

(Calculated in terms of rupees on the basic prices of the J.M.M. fixed in 1942)

Grading	*Clear & S.S.*	*Fair stained*	*Good stained*	*Stained*	*Heavily stained*	*Densely stained*	*Condenser chillas*	*Thick chillas or thin blocks*	*Thin splittings, chillas*	*Book blocks*	*Splitting-quality blocks*	*Total*
No. 1......	3.99	10.64	55.86	188.95	71.91	12.25	....	18.72	....	....	....	362.32
No. 2......	11.52	28.80	239.88	500.49	162.37	20.11	8.61	49.80	....	....	....	1,021.58
No. 3......	31.29	37.13	312.27	606.90	180.65	36.61	59.96	55.23	....	....	....	1,476.87
No. 4......	61.07	268.80	696.15	1,061.06	172.22	9.60	173.44	....	156.83	324.24	....	2,766.58
No. 5......	126.48	368.75	785.75	716.76	96.96	....	216.96	....	97.36	603.40	....	3,012.42
No. 5½....	48.50	210.76	399.56	359.68	39.81	....	114.11	....	54.86	272.20	....	1,499.48
No. 6......	76.73	309.26	538.02	654.98	....	....	....	....	....	....	1,398.32	2,977.31
No. 7......	....	....	....	275.68 (1-in. circle)	....	....	....	....	....	....	....	275.68
Total....	359.58	1,234.14	3,027.49	4,364.50	723.92	78.57	573.08	123.75	309.05	1,199.84	1,398.32	13,392.24

If a consumer of No. 5 book-form splittings were asked today * how much more he is paying for his requirement than he did in 1942, his reply would be 200 per cent, for while the Joint Mica Mission paid about Rs.3/8/– per lb. for this material in 1942, today * the United Kingdom government is selling its surplus stock of the same in the neighbourhood of Rs.10/8/– f.o.b. factory, India.

A consideration of such individual cases, however, can never give a true picture of the real change effected in the mica price structure taken as a whole. As has been explained in the chapter on the Element of Chance in Mica Mining, price changes are not uniform for all categories; nor is there any law governing the relations between these price changes. The changes occur under pressure of changes in the demand according to the well-known laws of supply and demand. Unless the calculation of the value of an average bulk of mixed or bima S.D.B. is made according to the different prices obtainable at different times for the entire range of the commercial group of mica, no true picture of the general increase or decrease can be obtained.

However, now that we have two sets of prices, one being the basic price that the Joint Mica Mission fixed in 1942 and the other the latest prices revised on Nov. 27, 1946, by the United Kingdom government for the disposal of surplus wartime stocks (see Appendix 1), for practically all categories of mica bought for one fixed standard of quality, *i.e.*, Joint Mica Mission standard, let us calculate the price of the average bulk analyzed in Table 53 according to the latest United Kingdom government prices. Table 55 gives this calculation and shows how the relative position of each quality has changed from the economic point of view.

Besides, though a consideration of the latest prices of a few categories in demand, such as book-form splittings, leads one to think that prices of mica have gone up by about 200 per cent or even more, the actual price increase that has been effected * so far for an average bulk of S.D.B. is, according to the above calculation, only 94 per cent or at the best 100 per cent.

The analytical results presented in the various tables can by no means be representative of individual mines or firms. As has been

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* Refers to condition in 1947, which remained unchanged up to 1949.

TABLE 55

THE VALUE OF EACH QUALITY OF DIFFERENT GRADES IN AN AVERAGE BULK OF 10,000 LB. S.D.B. IN BIHAR

(Calculated in terms of rupees on the basis of prices revised Nov. 27, 1946, by the United Kingdom government for the disposal of war surplus stocks)

Grading	*Clear & S.S.*	*Fair stained*	*Good stained*	*Stained*	*Heavily stained*	*Densely stained*	*Condenser chillas*	*Thick chillas or thin blocks*	*Thin splittings, chillas*	*Book blocks*	*Splitting-quality blocks*	*Total*
No. 1	6.00	16.68	99.51	372.30	149.47	23.93	....	38.91	....	....	....	706.90
No. 2	17.54	45.75	419.79	979.29	339.98	38.72	13.44	102.12	....	....	....	1,956.63
No. 3	46.93	60.71	558.79	1,179.99	377.32	71.44	93.60	112.14	....	....	....	2,500.92
No. 4	97.35	450.82	1,473.98	1,703.48	376.76	21.02	270.66	....	313.65	699.55	....	5,407.27
No. 5	210.80	677.36	1,484.19	1,153.98	192.36	....	385.70	....	321.30	1,781.24	....	6,206.93
No. 5½	76.86	391.79	697.52	719.36	68.80	....	232.18	....	109.73	987.92	....	3,284.16
No. 6	124.66	661.82	1,176.47	1,497.10	....	....	....	....	....	....	1,947.64	5,407.69
No. 7	....	....	....	563.36 (1-in. circle)	....	....	....	....	....	....	....	563.36
Total	580.14	2,304.93	5,910.25	8,168.86	1,504.79	155.11	995.58	253.17	744.68	3,468.71	1,947.64	26,033.86

explained in detail in the chapter on the Element of Chance in Mica Mining, the factors of grading and quality vary from mine to mine, from firm to firm, and even in the same mine from year to year or even from month to month. As a consequence of this peculiar feature, the value recovery of the crude, as calculated on page 295, differs widely with different concerns. Some firms' product may be luckily so superior as to fetch even 50 per cent higher value for the crude bulk, while in the case of others, the value recovery may be 50 per cent lower. Moreover, the production obtained from upperchella pits could not be taken into account in making the calculations contained in the preceding pages, owing to nonavailability of corresponding statistics. This also affects the results appreciably. Hence these must be regarded only as very rough estimates, which can give only an approximate idea of what an average bulk of Bihar S.D.B. consists of and of what is the relative importance or contribution of each member of the large commercial group of mica produced to the economics of the trade in general.

CHAPTER 13

Mica Piracy

Theft is a concomitant of property, and mica is as liable to be stolen as any other form of value in small bulk. The outcry is, as may be expected, as old as the evil itself, since practically from the very birth of the mica industry in Bihar, there have been men who have sought to give great prominence to the theft of mica from the mines. Then, as now, they raised a hue and cry, seeking government protection. Consequently, in 1932 the government of Bihar introduced special legislation to meet the evil. This was known as the Bihar and Orissa Mica Act. The majority of the mica trade was not in favour of it. This mica act was chiefly designed to render protection to the trade against illicit dealing in mica in the mica field, and thus the industry was under special government protection from 1932 to the end of 1938.

This mica act exercised adequate control over the trade by making it compulsory for everyone interested to have a license from the government authorizing him either to mine mica or to trade, as the case might be. The licenses were of two kinds, *viz.*, the mica miner's license and the mica dealer's license. On objection being raised by the zamindars (landlords) who own mica-bearing properties, they were exempted from taking mining licenses by the introduction of a proprietor's certificate, for which no fee was charged. Each licensee or proprietor's certificate holder was required by this act to keep a detailed account of receipts and sales of all mica, including the waste involved in manufacture. The place where mica was stored had to be reported to a special officer, who was designated as the Inspector of Mica Accounts—a magistrate with first-class powers. The movement of mica from one place to another could be made only on the strength of a pass, in a prescribed form, duly signed by an authorized agent of the licensee. This is in short how the mica act was framed.

After a thorough trial of 6 years, it was realized by the trade in general that the mica act was a failure and that, instead of helping the trade, it developed into a practice of unnecessary and undesirable government interference. There had been many cases where, even for technical infringements, many honest people were hauled up in court and punished, while the real culprits escaped easily by taking advantage of the loopholes in the act.

After the Congress Ministry came into power, the mica act was repealed in 1939, and no dissatisfaction was expressed by the trade in general aginst the action taken by the Congress Ministry in Bihar. Before taking this action the Congress Ministry held a number of general meetings in the mica fields to consult public opinion.

In 1940, after the outbreak of the war, the mica act was reintroduced under the Defence of India Rules in the form of the Mica Control Order of 1940. The object of the government of India in taking this action was stated as being solely to prevent the flow of mica into enemy hands. To take advantage of this government action and for a few other reasons, a section of the trade again started the old agitation over "theft of mica," which in their hands grew to the scale of "mica piracy." Considerable propaganda was carried on on this score. As a consequence thereof, the Mica Control Order was amended in 1944, prohibiting the sale of crude and bima mica, increasing the license fees from Rs.50/– ($15.22) to Rs.250/– ($76.10) and renewal fees from Rs.25/– ($7.61) to Rs.125/– ($38.05), giving discretionary power to the local government to cancel licenses without trial in the court, etc. Thus the control exercised by the government over the industry was made more rigid, though this action failed to quell the agitation and the propaganda that continued. It is necessary, therefore, to examine the whole question as completely and dispassionately as possible, with a view to ascertain whether any special legislation is at all needed to cope with the problem.

The first point to note in regard to mica piracy is that though its existence is admitted, its extent is purely a matter of surmise, rather than that of direct proof. It is guessed from the statistics relating to mica production and sales, and in this case statistics are of more than usually doubtful reliability, as has been indicated in preceding chapters.

Those who contend that the illicit trade in mica is on too big a scale to be ignored base their conclusions on the fact that there is a gulf of difference between the recorded figures of production and the quantities that are known to have been exported each year. It is argued that more cannot be exported than is produced within the country and that the difference between the two figures represents the quantities that are taken away from the mines and brought into the trade afterwards through the sales effected by the thieves themselves or the receivers of stolen mica. The possibility of other explanations for this difference is wholly ignored. One important fact to note in this connection is that the sponsors of this theory of large-scale theft have always contended that it is the cream of the production that is pirated. It is not realized that, if this contention is correct, it would be wrong to compare the total quantity exported with the total production of the year and such a comparison must necessarily lead to entirely erroneous conclusions. To arrive at a reasonably correct finding, the quantity of block mica (which represents the cream of the production) exported and that of splittings should be dealt with separately. To start with, a comparison between the quantity of block mica exported and that produced is essential. This comparison will prove or disprove the presence of the alleged illicit trade, especially in the cream of the production, and the extent thereof.

As has been calculated in the chapter on Descriptive and Analytical Statistics of Mica, the percentage of mica in an average bulk of S.D.B. that can be marketed in block or sheet form is in the neighbourhood of 28 per cent. Hence a reference to figures above the bottom row of Table 42 and a comparison of the figures contained therein with the percentage of marketable block, as stated above (28 per cent), will be found to dispel the discrepancy, which otherwise might suggest an appreciable amount of illicit trade in block mica.

We find a certain amount of discrepancy in the figures for 1934 and 1935, which can lead us to conclude that some amount of illicit trade in block mica was in existence. But in view of the various factors causing such discrepancies between the export and the production figures, the discrepancy that can be attributed to theft will be practically negligible. It may point to the existence of some amount of illicit trade, but not on a larger scale than is common in other spheres of trade.

This statistical study clearly indicates that, since no appreciable amount of discrepancy is found in blocks or the cream of production, the excess of export over recorded production will naturally have to be attributed to splittings only. The fact that the discrepancy in figures is shifted from block to splittings, though it weakens the case, does not altogether discard the need for explanation. Here the first and the most important point is the accumulation over a long period of splitting-quality mica obtained from the factory and the mine waste, which is neither included in the annual returns submitted to the Chief Inspector of Mines nor fully taken into consideration in the paying of cess to the government. Naturally it is not included in the total production of the Bihar mica field as it is given in the government records of the Geological Survey of India. Sir Cyril S. Fox has said that before 1920 the use of splittings was so small that the export was not even 25 per cent of what it was after 1920. But if it is remembered that the industry is seventy years old, then it will be realized that splitting-quality blocks were accumulated as dump during as long a period as 45 years. No statistics of this accumulation is available. This being an accumulation of over 40 years, it must perforce be on a large scale. There are stories current in the mica field that the large concerns sold their dumps to the newer concerns in olden days for lacs of rupees and that the concerns which bought them made fortunes out of these dumps. Prevalent folk tales go on to say that such dumps contained even considerable quantities of larger grades of mica, which were carelessly thrown away on account of the abundance of mica that was found right on the surface and on account of the smallness of the demand in comparison with what it is today.

Though all these stories are not dependable, the modicum of truth in them, however low it may be put, should suffice to explain the excess production of splittings. Moreover, in comparison with the average price of block mica, the price of splittings is so small that there is no incentive to anything except petty pilfering by the lowest class of labourers. The existence of illicit trade in anything but an inconsiderable form is extremely unlikely.

Besides, there has never been a regular demand for cheap mica splittings such as No. 6 third-quality splittings or cheap loose splittings. The absence of any appreciable demand for such splittings for, say, 5 or 6 years naturally results in the accumulation of thousands of maunds of inferior splitting-quality blocks recovered from the mines and the factory waste. When suddenly the demand for such cheap splittings becomes active, it absorbs the above accumulation and thereby adds considerably to the discrepancies between the quantities produced and the quantities exported and adds grist to the mills of propaganda.

Now let us examine the difference between the total quantity produced and the total quantity exported from 1931 to 1939. Table 56 gives us the relevant figures, and its study leads to some striking results. The mica act was brought into force in 1932 and was chiefly designed to protect this trade against "mica pirates." But if the figures must be accepted as correct, in comparison with 1931, when there was no government protection to the industry, we find an appreciable difference in the following years between the production and export figures, and when we come to the years 1935, 1936, and 1937, we find the difference increases considerably.

In 1939 the mica act was repealed by the Congress Ministry and the industry was again without government protection from 1939 to the end of 1940. It is, however, interesting to find from the figures of 1938 and 1939 that there was an excess of 20,000 cwt. in the production of 1938 (production of Bihar plus that of Rajputana) over the total quantity exported from the port of Calcutta. This naturally had to be carried over to 1939, which also shows an excess of production over export when the balance is added or even without the addition of the aforesaid previous year's balance.

If the official figures available are to be taken as correct, one arrives at the following conclusions:

That the mica act completely failed to render protection to the trade against mica piracy, but that on the contrary the trouble of theft in mica mines was rather aggravated, as is obvious from the figures for 1932-1937.

When the mica act was suddenly taken off the statute book in 1939, instead of a further aggravation of illicit trade, which was most naturally to be expected, we find an unusual amount of honesty in the trade, because the figures for 1938–1939 do not indicate any discrepancy, which is the only proof adduced in support of the presence of illicit trade in mica.

If the available figures are taken to be correct, the above conclusions must be admitted. But such conclusions can never be wholly true, because some of the alleged illicit trade in mica is incontrovertible. See Table 56.

TABLE 56

Difference between Total Reported Production of Bihar and Rajputana and Exports of Mica from Calcutta, 1931–1939

	1931	1932	1933	1934	1935	1936	1937	1938	1939
Total quantity exported from Calcutta, cwts.	33,056	31,205	35,816	55,702	76,114	99,491	134,425	79,618	106,991
Total production of Bihar, cwts.	31,720	24,097	32,674	45,979	50,821	71,738	85,978	84,235	86,765
Total production of Rajputana, cwts.	285	247	396	538	544	2,949	3,477	16,318	29,288
Total production of Bihar and Rajputana, cwts.	32,005	24,344	33,070	46,517	51,365	74,687	89,455	100,553	116,053
Difference between export and production, in percentage.........	3	28	9	20	48	33	52	21 (less)	8 (less)

The available figures of the total production of Bihar mica is no reliable basis for any conclusion regarding the existence of mica piracy; at any rate they have failed to give any idea of the magnitude of the evil.

This problem of mica piracy took considerable part of the Mica Enquiry Committee's time and the committee has made some very interesting observations after having gone through the matter in detail. Dealing with the arguments based on statistical discrepancies, the committee has observed:

> These statistics, therefore, do not establish the existence of a considerable amount of illicit dealing in mica, but the result is purely negative. It does not disprove the allegations of excessive theft, for the existence of legislation, requiring the keeping of accounts and the issue of transport passes, creates a tendency for stolen mica to pass through the books of dishonest miners and be reported as the output of their mines.

Now that the available statistics cannot be treated as a reliable basis for any conclusion regarding the existence of mica piracy and that at any rate they have failed to give any idea of the magnitude of the evil, let us pass on to a discussion of the various ways and means by which mica can be stolen from the mines and the factories. The agencies through which leakage can occur are:

1. The labourers working in the various mica mines and factories.
2. The weak points of the system of transporting mica from mines to factories.
3. The labour contractors working upperchella pits (surface deposits).
4. The managing staff of factories and mines.

It may be confidently assumed in the first case that theft of considerable quantities of mica is impossible. If the labourers are checked properly before they leave the mines or the factories they work in, leakage through that point becomes negligible. On the other hand, a defective system of transport facilitates an appreciable loss. Here is a concrete case.

In 1943, because of the shortage of petrol and tyres, the writer's concern started transporting mica from the mines to the go-down on the main road by bullock carts. The cartmen succeeded in bribing the durwaun who escorted the convoy and started stealing mica from the bags by opening up the stitches at the bottom end. They would take out solid pieces of larger grades and pack rubbish into the bags to make up the weight thus taken out or take out small quantities of mica from a number of bags and wet the bags to keep up the weight.

Information regarding this practice came to headquarters within a fortnight, and the writer intentionally slept on the matter for about a week more, while he sent spies to transact business in stolen mica with the cartmen living in the near-by villages. One night when the business was being transacted, the spies went to take delivery of the stolen mica, accompanied by the Inspector of Mica Accounts and a number of people belonging to the writer's concern. The thieves were caught red-handed while delivering mica to the spies, and the Inspector of Mica Accounts returned the next morning with his bag of eleven thieves and mica worth at least Rs.6,000/- to Rs.7,000/-.

This is an exceptional case, in fact the only one of its kind on government records, and the system of transport was responsible for the whole incident. It is hardly prudent to transport huge quantities of large-size crude mica on bullock carts under the protection of an ordinary durwaun.

The dishonesty of labour contractors working upperchella pits also contributes toward the illicit mica trade. Such upperchella pits are not guarded by an adequate number of durwauns; nor does the staff of the concern worry about them. The labour contractors work at their will, and a substantial portion of the cream of such production is invariably stolen by the labourers to be sold in the market.

But this factor can add but little to the total magnitude of the illicit trade. Besides, such contractors are indispensable, for it is economically impossible to work hundreds of prospecting pits departmentally, and since, as has already been said, science does not provide any practical means for prospecting mica, the search for substantial deposits will have to be left in the hands of these upperchella workers.

The theft of the "cream of production," as it is called, on any large scale is possible only when the managing staff turns dishonest and is hand in glove with a well-organized gang, which can pass the stolen mica on to dishonest miners. This is because, thanks to the Mica Control Order, the stolen mica must be legalized before it can be sold. The dishonest miners may solve this problem very easily by showing stolen mica as part of the production of their own mines. After the illicit mica thus obtained has been legalized, the entire bulk is passed on to the market as perfectly legitimate mica that nobody can challenge. The dishonest nonmining dealers can also utilize some amount of stolen mica, but in their case the scope is more limited.

Unless the management of a concern turns hopelessly dishonest, theft of considerable quantities of mica is virtually an impossibility. In such cases, one or two members of the managing staff also cannot do anything because the rest of the staff who are deprived of their share in such illicit transactions get jealous and probative information travels down to headquarters and leads to the detection of the theft. Remedy can be quick, provided of course the boss at headquarters does not sleep over the matter.

It will be seen from the above that the predominance of dishonest elements in the management accounts for more loopholes for theft than the existence of dealers, whose honesty is more easily impugned than that of the managers and mine owners. Undoubtedly certain firms lose considerably more than the rest. But it is also an open secret that such concerns have far more of such dishonest elements than the concerns that suffer less from theft than they. It may be said, therefore, that unless the integrity of the management is improved, the exclusive monopoly of the trade is given to one particular concern, or the domestic market is completely destroyed, no amount of legislation can help to rid the trade of this evil, for it is a case of saving some firms from themselves!

This is completely borne out by the dissatisfaction that has continued, perhaps in a greater degree than before the Mica Control Order was amended and made more stringent in accordance with the desires of the aggrieved parties.

Let us now examine the other side of the picture. The agitation that insists on state protection is vehemently opposed by a very large section of the trade. It is rather interesting to observe in this connection that most of the principal Indian producers, who must naturally be expected to be suffering equally, have joined hands with the opposition. This naturally leads one to the inference that either the management of these opponents is so perfect that they do not suffer at all, or, even if there is some loss of mica, the quantity involved is not worth bothering about. Another possibility is that, even if the extent of the loss is not negligible, it has to be balanced against some other considerations such as the harassment that is likely to be caused by injudicious administration of special legislation in this regard.

In this connection the Mica Enquiry Committee has made some very interesting observations, which are quoted below in full.

> The oral evidence on the point of theft is very conflicting. On the side of the opponents of special legislation for this purpose are ranged representatives of some of the biggest producers of mica in the area. If the agitation about theft is true, they are among the biggest sufferers. Hence, the committee has been at some pains to understand their attitude to this question. An indication of a possible reason is the suspicion, expressed by some witnesses, that there is an ulterior motive behind the agitation, and that an attempt is being made to force dealers and small miners out of the industry, and gradually to create a monopoly. That this suspicion is not confined to the witnesses only would appear from some of the questions put by the assessors during the recording of evidence before the committee, and, in answer to such a question, a witness of some standing in the industry stated that a suspicion of this sort was "in everybody's mind."
>
> This suspicion alone is not sufficient to explain the stand taken by these firms. Perhaps the real explanation is to be found in the nature of special legislation which hitherto has attempted to deal with the problem. It has been based on account keeping and the issue of passes to accompany all consignments of mica. It is generally agreed that this method has proved ineffective in suppressing the evil. All that a trafficker in mica has to do is to get in touch with a dishonest miner, and he is free to carry his mica about under cover of a pass, which no one can challenge. Similarly, it is a matter of simple bookkeeping for the dishonest person to keep accounts tallying with his stock, however it may have been obtained. On the other hand, discrepancies may creep into the accounts of an honest licensee, by reason of accumulations of small errors in weighing, loss of weight by drying of stock received in a damp condition, and other such causes, or because he cannot employ a good accountant. There is a strong feeling in the industry that the existing law has been enforced harshly against such innocent persons, and a reluctance to continue subject to this law. This is the feeling which led an advocate of action against mica theft to say to us, "I would far more suffer mica theft to a greater extent than to have the Defense of India Rules operated upon me," and again, "My contention is that whereas I want that sufficient security for capital should be there, but at the same time I should say that there should not be any laws which harass us."

These statements were made by an advocate of action against mica theft, in the course of his examination as a witness. In addition to his being an advocate of action against mica theft, the witness aforesaid is one of the few principal producers of mica of unquestionable honesty, who had enjoyed a very peaceful time during the regime of the mica act (1932-1938). This the writer says from his own personal knowledge both as an assessor on the Mica Enquiry Committee and as a man born and brought up in the heart of the Bihar mica fields. But the nervousness and apprehension which he feels today, which are obvious from the above statements, suggest a radical change in his usual outlook. This is rather surprising. What has caused one who raised no voice against the mica act to betray such nervousness today? His statements are suggestive of either a bitter personal experience at the hands of the administrators of the Mica Control Order or knowledge of some cases of gross injustice meted out to others.

It is clear that in these cases the people concerned realize that, in essence, it is a choice of evils. And if what one prefers is the lesser evil, the evil that he is anxious to avoid is greater. The injustice that one is likely to suffer from harsh laws seems more forbidding than the loss that one may be put to by the continuance of mica piracy. But the preference cannot remain the same irrespective of the loss sustained through mica piracy.

If those who took a leading part in asking for government action against this evil are still in existence and have been paying income tax regularly throughout all these years, then it is a fair inference that the extent of the evil is not so great as has been portrayed. If there are also people who would rather suffer some loss than expose themselves to the rule of harsh laws, then, too, it is a fair presumption that mica is not being stolen on any large scale.

The first step toward sound conclusions of this highly controversial question of laws against mica piracy is to recognize that laws against mica piracy are by no means the unmixed good that they have sometimes been represented to be. It is a question for careful consideration whether the gravity of the evil is large enough to call for any state interference. This is dealt with in the views expressed by one of the three most important producers of mica in a communication to the writer, which are as follows:

> Mica piracy, the much discussed problem of the field, is not a fiction but a fact, though much exaggerated. It is, in my opinion, an extremely difficult task to give any approximate estimate of the volume or proportion of mica that passes into the hands of the thieves. Coming pointedly to the magnitude of theft in my own firm, I am unable to make an attempt to conjecture what I am losing, but certainly it is not so large in proportion to the total volume of production as to affect my business appreciably.

Now let us take a broad nonpartisan view of the whole question. Though the effect of mica piracy varies widely with the quality of management and other factors, it must be recognized that mica, being as a rule value in concentrated form, is more susceptible to theft than most other commodities. Besides it is unidentifiable, and even if a theft is detected, one cannot bring the charge home to the criminal unless there is direct evidence or the circumstantial evidence is fairly strong.

Besides, the presence of a large number of dishonest dealers (both large and small) throughout the length and breadth of the mica field provides a strong temptation to people in the mica field, who are predominantly of the poorer class. It may be said, therefore, that even if the evil of mica piracy has been greatly exaggerated and even if it is not considerable now, it is capable of growing if it were left unchecked. Some measures which are capable of keeping the evil under check and which do not err on the side either of harshness or of leniency to real offenders may have much to be said in their favour.

Precisely this conclusion has been arrived at by the Mica Enquiry Committee when they say

> Undoubtedly there is an appreciable amount of illicit dealing in mica, and some firms suffer from it more than others. The conditions are such that complete elimination of it is not possible, but something should be done to keep it within reasonable limits, taking care that the legislation is not such as is likely to harass the honest members of the industry.

In accordance with the above findings, the committee has recommended a few measures, a summary of which is given in Appendix 2. These recommendations have been made by the Mica Enquiry Committee after bestowing great thought on the question. But unless proper and efficient management and supervision are ensured, whatever legislation may be framed in accordance with the above recommendations will be of little or no help.

There is however the question of the transport system to consider. One might argue that in the absence of good automobile roads adequate supervision may not be possible. This is one of the pleas that is often made by the advocates of government protection. But the roads are not so bad as they were a decade or two back, and even if something is lacking immediate steps can be taken to bring them to satisfactory conditions. The crux of the entire problem is self-protection through good management, and unless one is prepared to exert oneself to improve matters to the level warranted by the situation, no amount of legislation can render any appreciable protection.

While concluding their discussions on these recommendations, the Mica Enquiry Committee observed:

> The above recommendations represent the furthest that we are prepared to go in order to deal with the problem of mica theft. They will not eliminate mica theft altogether, for that is impossible; but they will, in our opinion, give the trade as much protection as is practicable consistently with the avoidance of harassment to honest members of the industry; and it is in this spirit that we would wish the law to be enforced. What we look forward to is, not an unthinking enforcement of the letter of the law, but a sympathetic administration by authorities who realize that the provisions are intended to help, and not to hinder, the industry.

It is extremely encouraging to note that the committee has taken full cognizance of the harassing effect that an improper and injudicious administration of the recommended legislation will have on the honest elements of the trade. It is a simple fact that, especially during the regime of the Bihar and Orissa Mica Act, many people suffered greatly for mere technical offenses.

There is no law that cannot occasion injustices if it is administered according to its letter and not its spirit. For example, reference is made to the provision that penalizes every discrepancy, however slight, between the account and the actual stocks. As rightly observed by the Mica Enquiry Committee, some amount of discrepancy is unavoidable and is bound to creep in. But the history of the Bihar and Orissa Mica Act tells us of many cases where honest elements of the trade were made to face the law irrespective of the spirit of it on account of such discrepancies. Hence, whatever legislation may be framed in accordance with the Mica Enquiry Committee's recommendations, it must necessarily be administered more in spirit than in letter through proper officials; as otherwise there can only be an unfortunate repetition of history—the last Bihar and Orissa Mica Act—when the prescribed remedy turned out to be worse than the disease.

CHAPTER 14

Conservation of Mica

Mica conservation shares with mica piracy more or less the same honour of being the main issue over which a great deal of heated controversy has been raised in the Indian press by certain sections of the industry. The main aim in raising the issues and investing it with an importance was to suggest that the industry was run predominantly by men of poor mental and material equipment, that the mine owners, for lack of proper equipment, resorted to methods which were immediately profitable to them but which were ruinous to the country as a whole, and that for such conditions there was no remedy except a system of rigorous regulation that will have no place for the inexpert or small-scale miner. Emphasis was laid on conservation of mica to prevent the alleged waste of mica resources by insistence on scientific prospecting and systematic development and exploitation.

In the chapter on Prospecting and Mining enough has been said about the present state of geological knowledge in so far as the mica pegmatites are concerned, and we must leave the work of prospecting to the upperchella workers. As things are, it must be admitted that they do the work with a degree of intuition and working efficiency that the geologist cannot pretend to or hope to attain in any short period. In spite of these incontrovertible facts, not only have the upperchella workers not been thanked for their contribution to the progress of the industry, but they have been derided as "surface scratchers" and the whole case for conservation is made to rest on the condemnation of their valuable work.

It has been claimed by a section of the trade that

> By the destruction of surface indications which are the only means of locating the existence of deposits, the future of the industry is imperiled[1] as

> it would be impossible without surface indications to undertake mining at all.
>
> There is such serious danger of the deposits being destroyed within 25 or 30 years by bad, injurious, and uncontrolled methods of exploitation that, unless timely steps are taken, we shall be condemned by posterity for wasteful destruction of one of India's natural assets.

One is led to the suggestion that there should be government regulations prohibiting the so-called "surface scratching" by a section of the trade. This suggestion leads one to think that some scientific methods of prospecting as an alternative are being offered for discovering new deposits. But it has been shown that the current practice of discovering workable deposits by upperchella working is the only possible way of discovering and working a mine. Mr. H. Hoover, a distinguished mining engineer and a former president of the United States, has said, "To the engineer falls the work of creating from the dry bones of scientific facts the living body of industry."

Unfortunately, the fundamental bones of the scientific facts leading to the discovery of mica deposits are still missing and as such any government regulation sought for their application sounds like forcing a man to march toward an objective that is unknown to the commander himself.

Add here the views of well-known experts on this question. The following expressed by Dr. J. A. Dunn in *Bulletin* 10, "Mica," published by the Geological Survey of India, in 1942, leaves no room for doubt that we owe practically all the mines we have today to the much maligned upperchella workers.

> Most of the mines operating today are reopened old mines which were originally worked either upperchella or down to water level and abandoned when pumping became too heavy to be dealt with by hand bailing, or by hand pumps, or when the ventilation became so bad that breathing was impossible or when the particular run of mica came to an end.

Dr. Dunn's views, given below with reference to the working of the mica deposits in the United States, show how universal is the present practice of upperchella workers.

> Most of the smaller veins are worked with little capital by individual miners or small groups of miners who mine out the vein as they go along,

using the minimum of machinery. Most of the larger productive mines are old workings which had been abandoned and reopened intermittently either because of such factors as vagaries in the mica shoots or because the mica market rendered them practically unattractive.

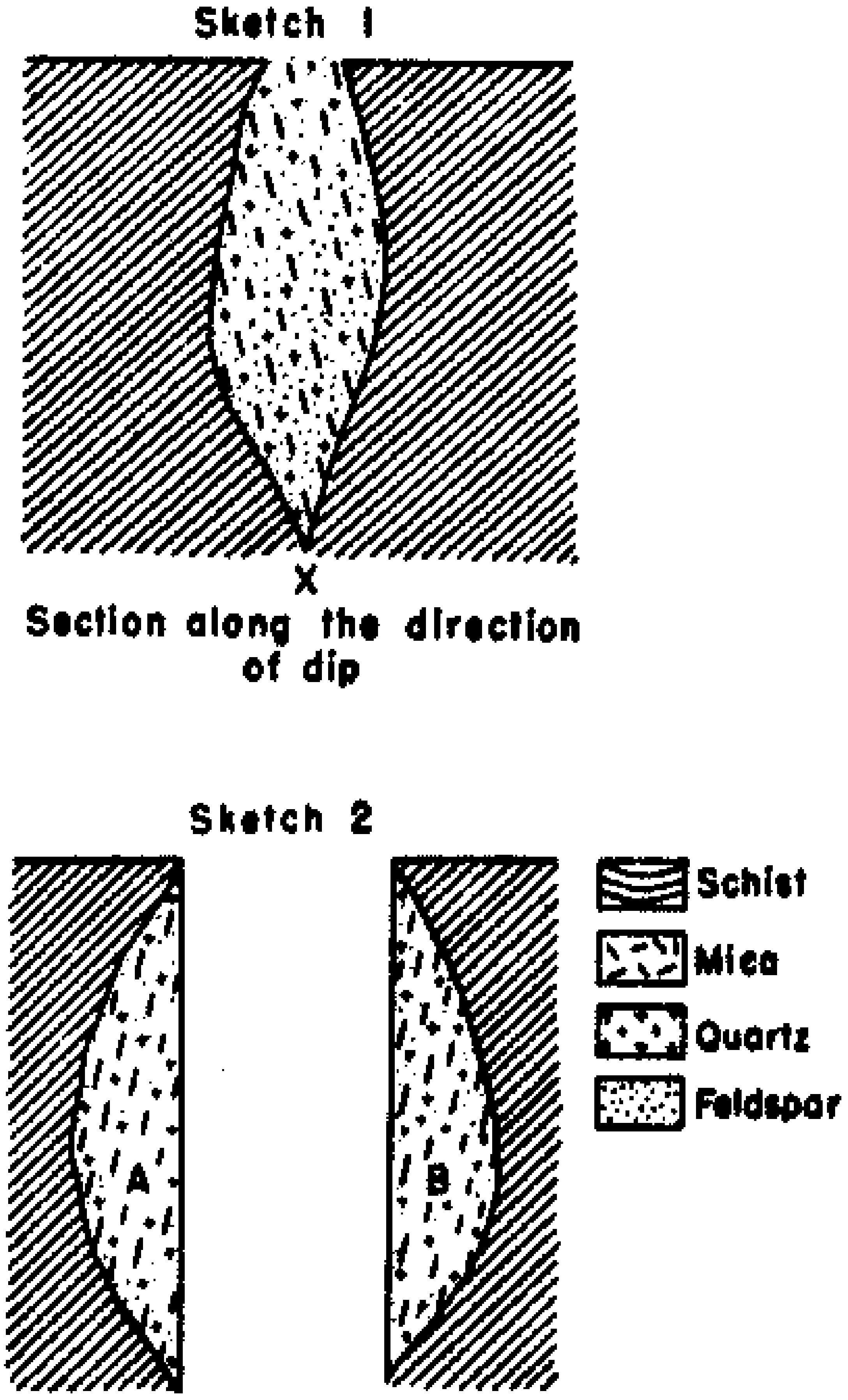

Fig. 84. Sketches showing what an upperchella worker may sometimes experience in mica mining.

This statement should show that the determination and methods of the upperchella workers are far from being frowned upon by scientists. Mining engineers have credited many prospectors with finding noteworthy mines in the United States, Canada, and Latin America.

A concrete case will explain whether this condemned practice of upperchella working really leads, as has been claimed, to the destruction of surface indications.

Suppose Mr. A with a small capital goes to a certain area, sinks a small pit of the type shown in Fig. 84 (sketch 1), and, after sinking it to a depth of 40 or 50 ft., finds the vein pinching at a point *X* as shown. As the mine yields no more mica, he must adopt one of two ways of treating it further.

1. He may stope out the sides of the pit for recovery of whatever mica is available, as shown in portions marked *A* and *B* in sketch 2, and abandon it.

2. In case he is adventurous and has sufficient finance he might sink further, going deep through barren rock beyond the pinching at *X* to see if there is another productive lens below for such adventures sometimes prove profitable.

The second method certainly is more systematic and scientific and would require simple equipment, such as a hand pump and a crab winch for pumping out water and removing debris. We are concerned, however, with the consequences of his adopting the other course of action. If Mr. A adopts the first method, which is crude, he does not in any way ruin the surface indications. Rather he makes the indications more conspicuous. He removes from the field only the more valuable mica; and small chips of mica along with the debris are always left at the pit head and are sufficient to attract the attention of even a passer-by, telling him that a man had at one time extracted mica out of this pit. All that he takes away from the field is his legitimate due, which he earned by investing money and sinking the pit.

If at a later date Mr. B with better financial standing acquires this very field, he finds some shallow pits at different places, some full of water and some full of debris. Before taking any definite step he would follow the general practice in the mica field of collecting information from the local people or the labourers who had worked for the previous owner, Mr. A, as to why the work in that particular area or pit was discontinued. The reasons for the abandonment are usually found to be one or more of the following:

1. The absence of mica after a certain depth.

2. Decrease in size and quality of mica, making the proposition unprofitable.

3. Working difficulties and lack of finance.

On receipt of such information Mr. B can more confidently judge for himself as to the extent of risk he would take. If he decides to work it, he cleans the pit, which presents no great difficulty, and proceeds with further development. There is one point, however: if Mr. B's efforts in continuing deeper should meet with failure, the whole of his capital outlay would be lost, since all the mica that previously existed was taken away by Mr. A. But since this is unavoidable, Mr. A cannot be blamed and Mr. B must consider it as a bad gamble or a piece of bad luck. From the view of exploitation, one can safely say that, instead of doing any harm to the field, Mr. A has done a lot of good by leaving history behind, which service would perhaps be appreciated only if good mica should be found deeper in the mine than Mr. A had cared to go.

From a production point of view, the contribution of upperchella workers is at least 25 per cent of the total production of Bihar. This is by no means negligible. If it is a fact that more than 98 per cent of what we see today as pegmatites are just shallow deposits and if the recovery of mica from these veins is made possible only by the upperchella workers, then it is not detrimental to the future interest of the industry and any government regulation prohibiting it will seal all chances of discovery of new deposits. Also it will make the important contribution of these upperchella workers to the total production of Bihar impossible. This production is not generally predominated by larger grades, but the smaller grade mica that is obtained is usually of a superior quality, for which there is always considerable demand.

The system of upperchella working creates employment for a considerable amount of labour, and any government regulation prohibiting the same will throw labourers out of employment. The industry will be denied the benefits of the natural instinct that upperchella workers have developed for prospecting of mica through years of experience and inherited aptitudes. The denial to the industry of this gift of nature will have far-reaching consequences in its future development. Unless some scientific methods are invented by some research institute to take the place of the present method, the industry should be allowed to continue using these upperchella workers, who are now the backbone of this industry.

Absence of modern methods of scientific mining, as has been emphasized on several occasions, is one of the chief factors jeopardizing this national asset. These facts have not prevented the assertion that "mica mining has now reached a stage when it cannot be properly developed without fairly expensive mechanical equipment, and when it should not be allowed to develop except under conditions of scientific mining."

To understand the problem properly, let us see what is really meant by "scientific mining." Scientific mining can be discussed under two heads:

1. Mechanical equipment required for working a mine.
2. Methods of mining required for developing and stoping a mine.

The extent of mechanical equipment required is solely dependent on the quantity of expected raising per day and the extent to which a mine can be developed in both vertical and horizontal directions. This gives an indication of the various problems to be dealt with in the exploitation of the valuable mineral. Considering the extent to which the largest deposit can be developed today, the requirements of mechanical equipment in the chapter on Mining should have made it sufficiently clear that mica mining does not need machinery that is so elaborate as to call for any highly specialized knowledge or so expensive as to justify the insistence that small units leave the field clear for the bigger ones. On this subject the following are the views expressed by the United States Tariff Commission, in "The Mica Industry."

> In the final analysis, the problem of how most economically to prepare for and conduct mica mining operations is baffling to the engineer as well as to the small miner, more particularly perhaps to the engineer. It is often said that modern equipment and methods are needed for the better exploitation of mica resources. But where the value that can be won is impossible to determine beforehand, the question of how much investment is justified is not easy to answer. If there were chances for very large gains, it would be a factor, as it is in many other mining ventures. But with mica, rich prizes are extremely rare—the best outcome that can reasonably be expected is modest.
>
> Should even half of this total come from a few, say, five or six, of the larger mines, it is obvious that no great investment in modern machinery or "dead-work" development would be warranted. In general, therefore, it is a fairly common rule that all work must pay for itself as it proceeds, a condition which naturally precludes much dead work. Moreover, there can be no such item, accurately determined, as "ore reserves" appearing as an asset

on the books of a mica-mining company, and a "reserve for depletion" could only be an annual write-off of some arbitrarily determined portion of the investment. Capital does not gravitate toward investments of this kind and so it is usually an impecunious prospector and not a well-financed company that is found searching for this important mineral.

In the United States and Canada there are several cases on record of mining operations which have been undertaken by large companies, amply financed and possessed of first-class engineering talent. Perhaps the best known of these is the venture of the Westinghouse Electric and Manufacturing Company in the Black Hills of South Dakota. This company undertook the development of a promising mica field on a relatively large scale, the financial outcome of which is not generally known. At three of its mines, the New York, the Crown, and the White Spar, vertical operating shafts were sunk in the country rock hanging wall, tapping the pegmatite dyke at considerable depth, and crosscuts (all through barren country rock) were run at different levels. At the New York mine, the vertical shaft was 315 ft. deep. Underground workings were electrically lighted and the pumps were run by electricity. The systematically well-run camps for the men were supplied with modern conveniences. Heavy boilers, engines, dynamos, motors, and compressors were hauled to the mines and installed at considerable expense. All such equipment and development work is usual at metal mines and some nonmetallic mines, but very rare at mica mines. Profit and loss statements and balance sheets covering this period are not available. It is known only that large quantities of high-grade mica were taken out and shipped to the company's plant at Lincoln (state of Nebraska), where it was graded and classified, punched to desired shapes by electrically driven machinery, and even split for use in making built-up board. All the mica thus produced was for the company's use, but in 1911, after 3 or 4 years' trial, the company withdrew completely from all such activities and purchased its mica sheet and splittings abroad. Modern systematic, well-financed mica mining in a prolific field had been given a thorough trial and was abandoned.

The following is what Dr. J. A. Dunn says in his aforesaid brochure on mica:

> A few mines are mechanically equipped and worked according to modern mining technique, but on the whole, attempts to introduce well-organized engineering methods have not been very successful. The reason for this appears to be due to the relatively small size of the veins and irregularity of distribution of mica.

In the light of the views expressed by various authorities, both in India and abroad, especially by those belonging to a country like the United States, the most progressive country in the advancement of science in the world, it can very easily be concluded that mechanization of mica mines cannot possibly be made very elaborate, except at a risk of serious loss. Most of the mines working today in India that can be called fairly large are mechanized with simple equipment. The author has developed a number of mines quite extensively up to 600 to 700 ft. in the direction of dip and about the same in the direction of strike, and even the largest of them did not call for more than Rs.50,000/- to Rs.60,000/- for proper mechanization.

Precisely speaking, the systematic development of a mine that is solely dependent on the dip and strike factor has practically nothing to do with mechanization. A mine can be developed quite systematically without the aid of any mechanical equipment. Mechanization of a mine is warranted only for an economic development of the mine, as discussed in detail in the chapter on Mining. On the contrary, mechanization is completely dependent on the systematic development of a mine. Unsystematic development may prevent a mine operator from deriving any benefit from his mechanical equipment. For example, in the absence of a straight shaft or an incline, it is absurd to install mechanical haulage. In case the water delivery pipe of a steam pump must be laid in zigzag fashion with an unnecessary and undesirable number of bends, the pump loses a considerable amount of working efficiency, and if the drives are not fairly horizontal, laying rail lines for the movement of tubs on the levels becomes impracticable.

The long and short of the whole thing is that systematic development of a mine is so clearly to the benefit of the operator that he should need no external compulsion to resort to it. Systematization does not make the proposition costlier. On the contrary, it leads to a more profitable development of a deposit by enabling one to take advantage of the available mechanical facilities. Systematization and mechanization are not synonymous terms—there can be system without machinery; and with the utmost mechanization, development can be unsystematic.

The most serious errors committed in this is that mechanization of mica mines is thought to be expensive. Those who think so do not understand what is really meant by the term "expensive." Perhaps it is simply a bogey raised by a section of the trade who seek government regulation with the hope of eliminating the smaller units from the trade.

Factors that determine the method of mining are

1. Possible extent of the lode or the vein both in the vertical and in the horizontal direction.
2. Thickness of the lode or vein.
3. Dip of the lode or vein.
4. Hardness of the deposit.

Modern mining methods are designed to suit conditions where the expected production from the mine is expressed in terms of hundreds of tons per day, and the expected expanse is at least over a thousand feet in the vertical direction and over a mile in the horizontal direction. There are a number of scientific ways of ascertaining the true nature and extent of an ore body and thus reducing the gambling element. But unfortunately for mica, present-day science so far has been a complete failure in providing protection to this industry against the great risk involved in determining the extent of a deposit.

The deepest section of a mine yielding mica today may suddenly turn barren tomorrow. There is no guiding principle to tell us whether the mica will reappear in the pegmatite. It may or may not, and this is the worst part of the venture. It is on this account that it is said that mica mining is wholly a prospecting job till stoping begins. On this aspect, the views of the United States Tariff Commission are conclusive:

> Very little information is available concerning mica mining conditions in other countries, but as the nature of the occurrences of mica is almost identical in all localities, the methods of recovery are also much the same. One controlling fact is that mica rarely if ever occurs as a persistent seam; it is spotty and irregular, and when a pocket or streak of book mica plays out, it is impossible to say where or in what quantities its continuation, if any, may be found.

Returning to the main subject, it must be admitted that even in the largest mica mine that we have today, the raising is not even 50 tons per day. Moreover, the extent to which the biggest mica deposit can be developed today is very small in comparison with that of other metalliferous mines, calling for installation of elaborate equipment. Consequently only machinery of the simplest type can best meet the requirements of mica mining. After all, the aim of applied science is increased efficiency in working, leading to profitable development of a valuable deposit. Failure from the business point of view is not less repugnant because it comes after complete mechanization.

The science of metalliferous mining chiefly deals with the subject of stoping, which consists of a number of methods depending on various lines:

1. Width of the lode or vein.
2. Dip of the vein.
3. Stability of the hanging wall and the footwall.
4. Hardness of the deposit, etc.

The exhaustiveness of the subject is attributed to only one factor, and that is to achieve steady production for the regular supply of ore to one or several plants set up for the extraction of the mineral from the ore. Therefore, stoping must be done simultaneously with development, and the entire production from stoping hauled up to the surface for separation of valuable metal from the ore. This type of work requires elaborate protection of the mined-out areas.

As explained in the chapter on Mining, most of the product of blasting can be left behind in the mine for backfilling. The cost of removing the broken material becomes practically nil and at the same time adequate protection is rendered by such waste materials to the mined-out area automatically and without any cost. The United States Tariff Commission's views on the modern methods of mining are as follows:

> Proponents of modern methods and equipments will argue, and perhaps correctly, that the output of mica in the United States might have been much greater than the 15 year annual average if modern methods had been followed. But this is conjecture. There are, in the United States, several fairly large mines in which persistent streaks of bodies of mica appear that have been worked in miner-like fashion, using air drills to drive, full-size tunnels, drifts, or up-raises, provided with underground tracks, drainage, chutes, ore pockets, etc. But when the pay streak has pinched or disappeared, and when the operators are faced with the dead work to find it again, dead work that may call for only a few feet, but that might run into a hundred feet of drifting

or sinking through barren pegmatite formation, most of these mines close down.

Under the circumstances described above, the systematic development of mica mines does not call for an elaborate knowledge of scientific mining in the sense of close acquaintance with the various academic issues. It cannot be denied that mica mining has a technique of its own. The technique in mica mining is very simple, depending mostly on common sense.

Now let us examine the issue that has been raised in connection with the wasteful methods of mining pursued by most of the Indian miners, which, it is alleged, threatens the longevity of India's national asset. None who has the slightest amount of love for his country would hesitate a moment to agree with the view that we should take care that "we shall not be condemned by posterity for wasteful destruction of one of India's natural assets."

But now the main point to be decided is whether the methods of mining now adopted in the Indian mining are so "injurious and uncontrolled" as they are made out to be.

For this, let us take a case as shown in Fig. 85. This illustration shows in the hatched area a typical section of a mine worked unsystematically. The miner from a point on the surface detects the mica-bearing pegmatite and starts sinking through it. When he reaches a point, he finds more concentration of mica toward the right and then at a point again he finds comparatively better concentration toward the left, and he turns toward the left. Following concentrations like this he develops the whole mine up to the extent he possibly can, completely ignoring the dip and strike factors.

When he reaches the points, he finds it practically impossible to develop the mine further because of the difficulties and the cost involved in removing the debris and bailing out water by hand labour from these points. Hence he must either abandon the mine or straighten out the mine for installation of proper equipment. In case his purse does not allow him, he stopes out the mine partially as shown by the hatched lines or the whole as the case may be, depending on a number of local conditions, such as hardness of the deposit, stability of the hanging or footwall, etc.

The question is which is more adversely affected by this, his action, his own interest, or the long-term interest of the industry? It has been discussed in detail in preceding pages that the most difficult part in the mining of mica is finding a prospective pegmatite. But if in spite of having been lucky to hit on a good pegmatite, one abandons it, or is forced to abandon it after having worked it up to a certain extent because of lack of knowledge of proper mining methods, it is his own interest that suffers more; and that is sufficient punishment for him whether he is guilty of remissness or incompetence.

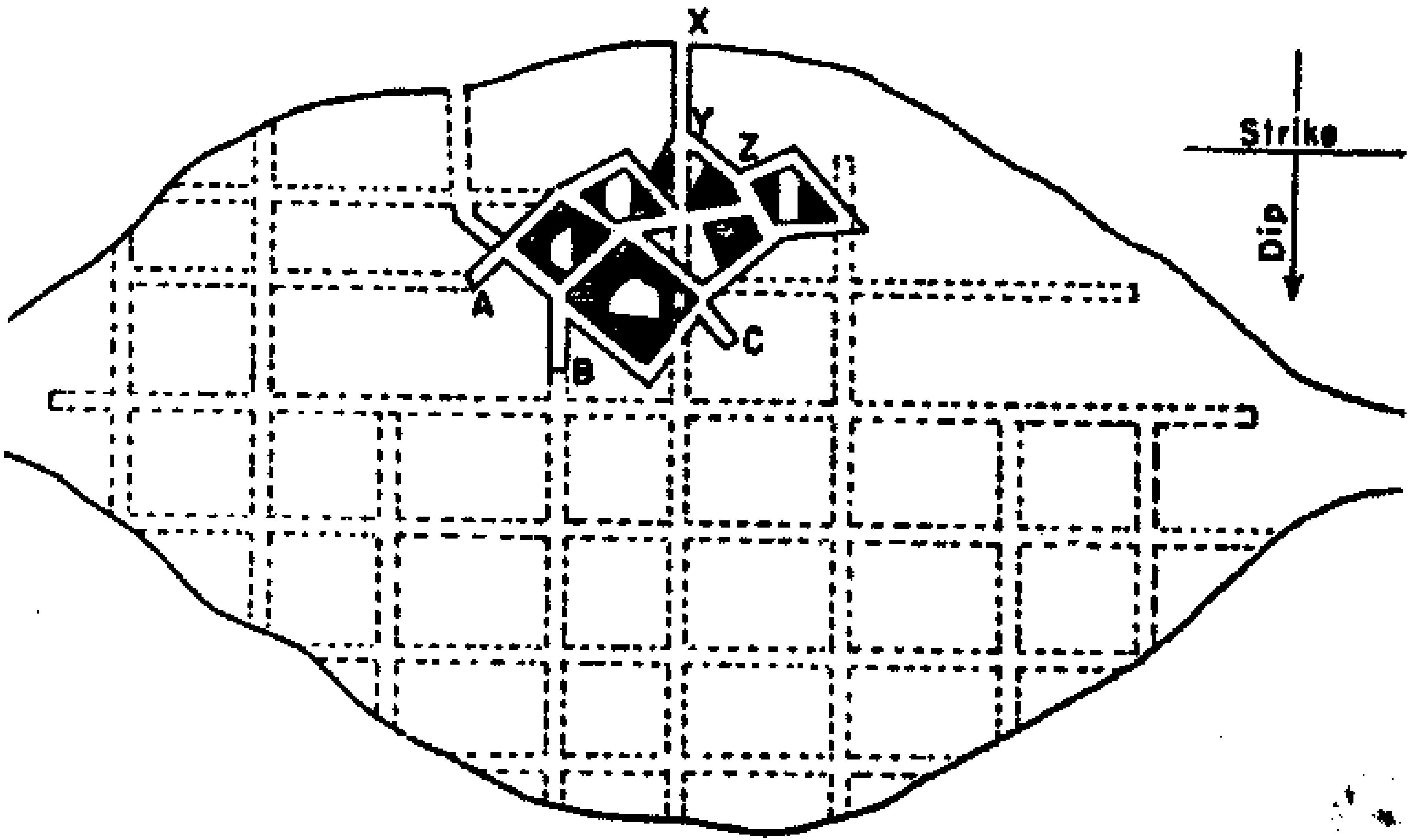

FIG. 85. An example of how a mica deposit may be mined unsystematically or systematically.

As for the interests of the industry, let us see what happens to this deposit after it has been abandoned in the way described above. The fact that the deposit contains workable quantities of mica obstinately lingers in the mind of its owner; and though he has yielded to the inevitable, he exerts himself to get the best out of it by selling it to a prospective buyer. Ultimately, this property usually passes to the hands of a better man. He reclaims it and straightens out the old workings, and by developing it systematically, enjoys what his predecessors have had to throw away.

In the light of the foregoing, it can very easily be concluded that if one is lacking in the knowledge of the proper technique of mica mining, he penalizes himself but does little harm to what remains of the natural asset. Most of the mines that are working today with a bit of mechanical equipment were, originally, worked in a manner similar to the one described above. The author has himself straightened out more than a dozen such mines without much difficulty.

Now, one may say that this involves considerable expense. But even if it does, one has found a greater degree of safety in investing money in such mines than in groping in the dark to find a prospective deposit. The previous owner, at least, solved the most difficult task of finding a deposit for which his reward is, if anything, on the low side. Nature punishes him by depriving him of a major portion of the profit that he could have earned by exploiting the whole vein systematically. The lion's share of the profit is, thus, enjoyed by one who goes and works and straightens it out without undergoing the strain of prospecting the deposit himself.

It can very well be said that such a worker does no harm to the field. On the contrary, he renders some service by finding a vein, possibly through luck or through his efforts, and thus no natural asset is lost for good.

The United States Tariff Commission states it as follows: "An old abandoned mica mine is often a better prospect than a new, undeveloped body of pegmatite."

In conclusion one fails to understand what is really meant by the so-called "wasteful" method of mining. In fact there is hardly such a thing as a wasteful method in the mining of mica. If at all one insists upon entertaining such term, it must, however, be exclusively confined to the economics of the problem. A method may be called economically wasteful if it ultimately reacts badly on the loss and profit account of the individual.

Lack of the requisite knowledge of systematic mining causes a progressive increase in the costs of production as the mine goes deeper and the workings underground become more and more extensive, and the operator is ultimately forced to discontinue his mining operations completely. Such cases of failure have not been few. In fact, it is due to the adoption of economically wasteful methods of mining by those who have been lucky enough to spot rich mica deposits that most of the big mine operators of today are reaping the harvest sown by those who suffered from incompetence or ignorance. Failures due to such incompetence or ignorance deserve no more blame than those caused by over-ostentation and unduly top-heavy management.

There are many examples in the Indian mica field of failures, including those of the former government of India during World Wars I and II, attributable solely to their thoughtlessly trying to apply elaborate metal mining methods in mica mines. Their overhead charges and initial capital investments were so heavy that, in spite of the unquestionable financial soundness and technical competence that they possessed, they were forced to quit the mica field for good. Those who subsequently acquired the properties and equipment of these unfortunate entrants are flourishing today in spite of their comparatively weaker financial strength. This has been so, because they knew the tricks of the trade. Such imprudent elaborations have been found to be no less wasteful and disastrous in their consequence than those caused by incompetence or lack of the technical "know-how."

If such wasteful methods are referred to in connection with actual loss of valuable mineral, it makes no sense. Unsystematic mining is limited to shallow depths; and, however badly a mine may have been worked, it can easily be reclaimed at reasonable cost, provided there are dependable records to justify an investment. These wasteful methods entail no loss of mica. In a few cases, because of some exceptionally unstable local conditions, some mica may be lost, even if the mine is properly reclaimed. The loss, however, in such cases is so very small that it cannot bring any perceptible effect to the industry or to the nation.

It is hardly to be wondered that those who seek to give so much importance to unimportant problems should deny those which are really important. For reasons best known to those who have raised the hue and cry against the smaller miners, they have kept the public in the dark about the factors and circumstances that cause a real waste of Indian mica resources.

Half a century of practical experience has not been sufficient to prevent propagandists from giving rise to considerable controversy with regard to the depths of mica mines. A responsible geologist has gone to the extent of making the sweeping statement that "contrary to the belief of the mica experts of India, who consider mica to be merely shallow deposits having originated from surface water circulating along fault planes, it should be clearly understood that all mica mines go very deep."

It is difficult to understand how anyone with a reasonable knowledge of geology can afford to make so categorical a statement on this subject. Considering the geological aspects and the various theories as to the origin of mica pegmatites, it is established that, whatever may be the source of formation of mica, mica was crystallized or formed at a certain temperature and pressure, some millions or billions of years ago. Since its formation the entire surface has been exposed to extensive erosion and it is not accurately known to the science of geology what thickness of the earth's crust had been denuded and carried away from the mica fields by natural forces.

Therefore it is a highly unwarranted assumption that all the pegmatites have concentration of mica up to any fixed depth. It all depends on the extent to which a particular area or a particular pegmatite in an area was subjected to such denuding. Reference to Fig. 86 is made to illustrate this point more clearly. Suppose in the particular area where mica pegmatites were formed, the hillock *A*, which has a very rich mica-bearing pegmatite, was in existence. As a result of denudation, the hillock was eroded and only a part of lens *C* remained exposed on the surface. At the time of crystallization, the required temperature and pressure conditions were available only at point *C′* of lens *C*. So, if this lens is worked, mica would be found only up to a depth indicated, after which the entire mass of pegmatite, if any, might be completely barren. If the area had not been affected by denudation, a cumulative extent of the lenses would have produced a very large mine.

It is not exaggerating to say that the quoted statement by the geologist in reference to the depth of mines means practically nothing.

The chapter on Processing shows the extent to which mica is a victim of careless handling by factory labourers. Unfortunately vociferous enthusiasts for conservation have very little to say about this vital waste of valuable mineral, especially in the factories of those who profess so much anxiety for conservation.

It is surprising to note that no efforts have been spared to seek protection for the invisible asset, *i.e.,* the unexplored deposits, while nothing has been said about the criminal waste of mica which takes place every day in a mica factory and which could easily be minimized by careful supervision.

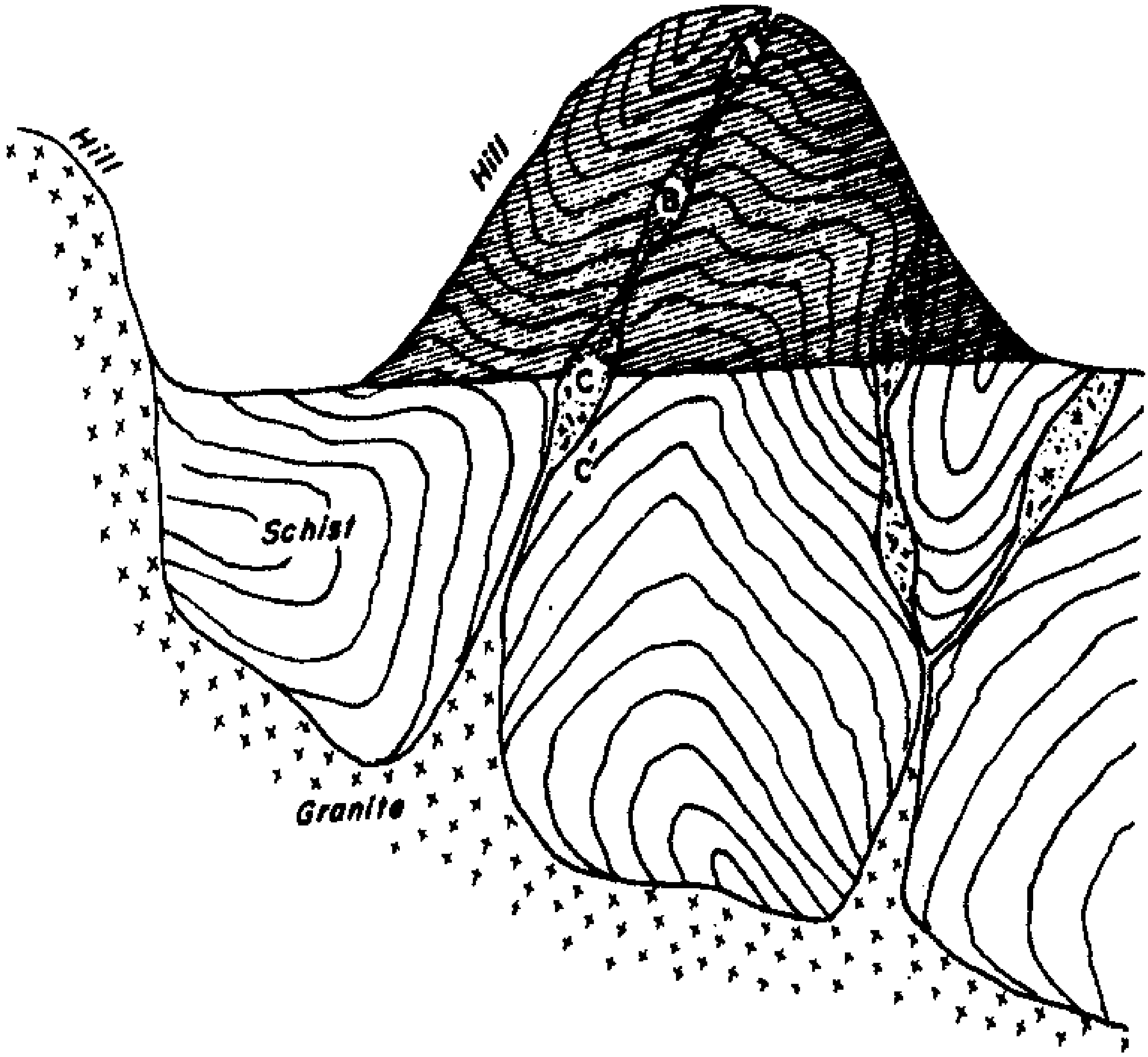

FIG. 86. Diagrammatic sketch showing how mica ore bodies may have been eroded, leaving only shallow deposits.

Also, the dependence of mica on visual tests for electrical purposes is another source of undesirable waste. As stated in the chapter on Standardization of Qualities, no effort has yet been made to check this waste either.

Last, but not the least, the amount of mica that is left behind in the mine with debris at the time of stoping hits very badly the point of conservation. It might be argued that loss of mica at the time of stoping does not exist, but to prove it one need not go very far. It is claimed that since the mines are located in deep forest areas, it is extremely difficult to keep adequate guard over the mined product, as a consequence of which some in the industry claim to have lost the cream of their production continuously for the last three or four decades.

Not all the people engaged in mica mining have made the same complaint, and it is fair to suggest that, if some people regard the prevalence of theft as a threat to their very existence, it must be attributed to the incompetence of the staff. A staff that is so negligent in the simple matter of protection of the property is not likely to be efficient in recovering the full extent of mica at the time of stoping.

One cannot but conclude that the entire blame has been thrown on the shoulders of the smaller elements and the upperchella workers with an ulterior purpose, and this condemnation of the small-scale workers can find little support in the facts of the industry and the trade.

The real offenders of conservation are not the smaller elements, but some of the large producers who in recent war years stoped out fairly deep mines without developing the proved mica veins to their full extent. Whatever mica is buried below the products of blasting is lost for good and no one can possibly undertake to reclaim these mines, for nothing can guarantee him even the bare redemption of the capital he may have to invest. He may clean the entire mine and find the deepest point yielding mica, but it may turn barren after a few feet of development in the deeper sections.

From views expressed by foreign authorities on the mining of mica, one can see that, even in countries like the United States, such conditions and experiences are not much better than they are in India today.

The things said by many against prevailing conditions in the mica-mining industry of India are far from correct, and conscientious mica miners need not suffer from the thought that posterity might condemn them for wasteful destruction of one of India's natural assets.

Generally speaking, present conditions in the mica-mining industry are just what they should be under present circumstances. Except for a few regulations with regard to keeping of proper records and limiting the activities of smaller miners to certain prescribed depths of, say, 100 ft. vertically, any effort to regulate this industry to combat imaginary evils would, far from helping the industry, throw it completely out of gear. Reformist zeal is better directed toward correcting waste of mica in the factories, in consuming centers, and in the mines at the time of stoping, all of which can easily be achieved by a little extra care.

CHAPTER 15

Conclusion

The reader who has gone through this book up to this stage will probably want to be told something about mica mining as an avenue of enterprise and investment. Enough has been said in the foregoing chapters about the highly speculative nature of mica deposits. Because of their smallness they do not afford sufficient scope for the application of modern mining methods.

The chapter on the Element of Chance in Mica Mining explains how loss and profit are dependent on numerous factors completely beyond human control because of the intractable nature of the cost of producing the goods for the market. To this must be added the incidence of cyclical boom and slump. In the case of mica, the slumps are generally uncommonly long, while the booms have been found to be very short-lived.

These features, peculiar to the mica-mining industry, virtually leave but a very small margin of profit to an average miner. Many, both big and small, have taken to this industry and have been patiently adhering to it for a number of decades. But save a very few lucky exceptions, none has yet been able to build up a fortune to be able to stand at par with adventurers in other industries.

Precisely the word "heritage" is not at all a misfit in expressing the intensity of attachment that develops in a man born, so to say, with mica in his blood. It has been aptly mentioned that "though there are exceptional cases where a lucky coincidence of uncertain factors has made for large fortunes, a modest return is normally a rich prize." But in spite of the extremely small profit that an average man earns in comparison with the amount of risk, labour, and hazard involved, the everlasting hope that tomorrow will bring better results keeps the man perpetually entangled in the web of mica.

Nevertheless, at cooler moments, perhaps when good sense prevails, one feels a lack of security in the complete dependence on mica. However, the sudden appearance of an accidental success or of a few lucky episodes acts as an anesthetic in sending such "good sense" back to sleep, and thus the person so "addicted" to mica chooses to live on his hopes again. This tug of war continues from generation to generation, but the mysterious effect of mica mining is always to attract the mica miner and when adversity, the frequent visitor to the mica field, comes, he is again at his wits' end to know what to do.

Small profits are rarely found to be an effective deterrent from engaging in a field that is generally thought of as a speculative one, holding out rich prizes for the lucky and the enterprising. In all fields of business the public has its gaze fixed on a small number of known successes and has no thought for the failures, who are as numerous as they are unknown. Hope always surges in the human breast and a few suffice to beckon the many to dangerous and treacherous paths. A boom, however short-lived or illusive, has the effect of encouraging a large number of adventurers to rush to where the more experienced tread warily. Adversity loses its sting when it is opposed by cupidity stimulated by the spectacle of outstanding luck. To those who are in the trade or rather born to it, there is not the sense of quitting or sticking to it. Mica is in their blood. They have inherited the trade, and they are bound to it. But to outsiders, it would be wrong to present it in any other light than that of a gamble.

It might be thought that the shadow of gloom that has been spread over the mica picture in the opening paragraphs of this chapter is in the nature of special pleading of one who is in the trade, and is, therefore, designed either to secure a monopoly of its rich prizes for himself or to reduce the competition for them in so far as it may be possible. As a businessman, the author may be acquitted of belief in such crude methods of gaining his ends.

It is in fact a statement of the unpleasant truth, and one could see no way to suppress the facts that are relevant to the theme on hand.

It is not with a view to discourage or to dishearten but to caution the new adventurers, who usually enter the field attracted by the prosperity of a few lucky exceptions and cherishing a very high degree of optimism in spite of information about the misleading and treacherous features of mica, that the opening paragraphs of this chapter have been devoted to the recital of unpleasant facts. There is indeed the comparative side of mica that cannot be suppressed. Those who return to the races again and again in the face of repeated failures and losses will find nothing in mica to scare them away. Mica is no worse than any such speculation. One who sticks to it gets at least his living wages. One who falls in mica, rises again in mica, and if one is particularly lucky, his fortune knows no bounds.

It is extremely difficult in the first place to say whether it is suited best to the rich or to the poor. Nor is it possible to say which of the two is more prone to its disastrous effects. The mica industry affords scope for investment alike for small sums and big. With a capital of Rs.400/- to Rs.500/-, a man can work the shallow deposits on the principles of upperchella working and earn a profit of 5 to 7½ per cent over the weekly turnover. Hundreds of people are earning their livelihood in the Bihar mica field in this manner. But there is also scope for investment in terms of thousands. There are numerous such investors in the mica field working one or two fairly deep mines. Mica is not for this reason to be regarded as a small-scale industry, since it is an avenue of investment in terms of lacs as well. A few concerns of substantial magnitude, having a control over practically 70 per cent of the mica exported from India, are also in existence. The activities of such concerns are spread over very large areas and a considerable number of both big and small mines, and a large number of prospecting pits are under their management and control. But neither the importance of the smaller units nor the value of their contribution is to be judged by these figures.

A thorough analysis of the experience of half a century will show beyond any doubt that, though the return in most cases is modest, it is enjoyed only by those who have stuck to the industry with an untiring perseverance. Unless one is exceptionally lucky, it is idle for a new adventurer to hope for a quick return.

This is evident from the results of the war period. The boom in mica attracted a number of new adventurers to the field. Many of the properties they acquired were supported by exceptionally bright geological reports pointing to the presence of rich deposits of mica. These people carried on prospecting quite extensively in these areas with an amount of optimism that took no account of the uncertain nature of these pegmatites. With exaggerated ideas of the achievements of the science of geology and the working of other mining industries, they drew up their plans on the opinions of qualified geologists and engineers and cared little for the facts of the trade. The results may be easily imagined. Not one of them has established himself in the industry and many have already quit the field after sustaining heavy losses.

The handicaps that nature has imposed on this unfortunate industry are heavy enough in all conscience, as has been shown in the foregoing chapters, especially in the chapter on the Element of Chance in Mica Mining.

Besides, the problems confronting the industry since its very inception, plus those increasing rapidly with the march of time, are so intricate that, in spite of 2 years' honest and hard efforts, the Mica Enquiry Committee could not possibly make its report a very conclusive one. A major part of the Mica Enquiry Committee's time was consumed in solving the two highly controversial problems of mica piracy and conservation of mica. So far as the illicit dealing in mica is concerned, the remedy that has been suggested will have but little effect on the industry, because the Mica Control Order, which is much more stringent than the legislation suggested by the Mica Enquiry Committee and which is still in force (Mica Act, amended) has so far failed to produce much effect. On the contrary, if the suggested law is not administered judiciously and corruption creeps into the administrative machinery, instead of being helpful to the industry, it will be a source of immense harassment to the honest elements of the trade as indeed it has been in the past. In view of the manner in which theft of mica from the mines has become rampant and is riding a rising tide in the areas located near villages full of petty dealers, drastic measures have indeed become essential to check this menace! Considering the smallness of the industry in terms of annual turnover on one hand and the vastness of the mica area to be taken care of on the other, any remedy that may be expected to be reasonably effective will be prohibitively expensive. In the final analysis this evil can be fought best only by individuals through better supervision and employment of a reasonably well-paid and honest staff.

On the problem of conservation, there is practically nothing to comment on the recommendations of the Mica Enquiry Committee. Precisely they take good care of this problem so far as the mining side of the industry is concerned, without appreciably upsetting or interfering with the existing arrangements. Lack of sufficient data prevented the committee from suggesting a remedy for the colossal waste of mica that takes place in mica factories, especially in some belonging to the principal producers during the course of processing. This problem can be taken care of only through a high degree of meticulous supervision and a constant effort to increase the percentage of yield of finished product from the crude. This again can be achieved best if the product of the same mine is treated in two or three different factories situated in different localities so that a comparative idea of the average yield may be obtained. There is no formula governing the factor of yield, especially in the preliminary rifting and dressing operation of the crude.

Considering the existing state of Indian affairs and whatever connection they may have on the form and manner in which mica is usually exported from India, the attempt to save mica on any suggested plan in the factories will effect but a partial saving, because practically no one in the Bihar mica fields has any appreciable knowledge of mica's numerous uses or of its various physical, thermal, dielectric, and other properties.

Neither the consumer abroad nor the producer at this end has ever tried to come closer to the other, to understand mutual problems, and to make the best use of mica. Tests carried out by the Bell Laboratories, New York (referred to in the chapter on Standardization of Qualities), proved beyond doubt the crudeness of the visual test on which the assortment of mica in terms of quality has been dependent since the beginning of the industry and how much saving can be effected by adopting electrical methods of sorting mica. It can be reasonably expected that, if mica were processed in

India with a proper understanding of consumers' specifications, waste in the factories could be reduced considerably. Of course, the maximum efficiency can be obtained only if India starts on the manufacture of mica products.

From the present Indian standpoint, however, excepting of course the economic value of the mica-mining and -processing industry, nothing much can be said about domestic consumption of mica. It is strictly limited to repairs of electrical appliances used in India, to the manufacture of lantern chimneys, to the purpose of decoration on festive occasions (seldom), and to its uses as an ingredient in the temporary dyeing of cloth, especially saris worn by Indian ladies, for the presence of coarse mica powder produces a glistening effect on the dyed fabric. The various railway companies in India consume both sheet and built-up mica, mostly for repairing the worn-out electric units they use. Some important electric supply companies and tramway companies, such as the Bombay Electric Supply and Tramway Company, also use mica both in sheet and built-up form. The manufacture of electrical domestic heating appliances has recently started in India on a very small scale. Hence some quantity of electric quality mica also is absorbed by these small concerns. But as has been recorded in the Mica Enquiry Committee's report, most of the consumers alluded to above had been till recently securing their requirements from abroad. Nevertheless the total quantity of mica required by these domestic consumers is not very great. The Indian mica industry depends solely on sales to the electrotechnical industries of the outside world.

The problem of creating a domestic market for mica often gains prominence, but the complete absence of any important electrical industry in India makes it, for the present, not very promising. Unless and until India is on a par with other progressive countries in respect to electrotechnical industries, Indian mica will continue to be helplessly dependent on foreign markets.

It is often argued that the aforesaid helplessness of the Indian mica industry, which can aptly be called one of the chief contributory causes of the rickety growth of this industry, can be narrowed down considerably by undertaking the task of fabricating mica products in India. Such an effort will not only help to conserve mica to the maximum extent but will also go a long way in enabling the producer to earn a reasonable margin of profit, labour to earn adequate living wages, and the consumer to get his requirements at a much cheaper price than he, of necessity, has to pay today. There is indeed merit in this contention and no one would argue the fact that successful efforts in this particular line will solve many of the congenital problems of the Indian mica industry, to the benefit of all concerned.

The vastness of the distance between the producers' and the consumers' countries, making quick and economic transport impracticable, on the one hand, and the frequent changes that often take place in the specifications of the consumers, on the other, are claimed to be the most outstanding obstacles to the fabrication of mica products in India. These claims are largely true. But there are also items whose fabrication or partial processing do not call for a very high technique or a large capital investment and are free from the aforesaid difficulties.

The development of better Indo-foreign understanding and cooperation will help the commencement and growth of the manufacture in India of at least some mica products, and considerable improvement in the present industrial structure can be effected. In the final analysis, however, the salvation of the industry lies in the establishment of heavy electrotechnical industries in India.

It is well known that the labour charges in the industry as a whole increased by at least 100 per cent (1947) after the end of the war, affecting the cost of production seriously (labour alone accounts for more than 60 per cent of the total cost of production) and thereby making it necessary for the producers and the processors to raise their prices. However, it may be admitted that, considering the abnormal high cost of living, wages were still not adequate. It has been explained in the chapter on A Study of the Descriptive and Analytical Statistics of Mica that the price of mica, on the average, had increased only by 94 per cent or at best 100 per cent (1947) in comparison with the Joint Mica Mission basic prices fixed in 1942 (which were practically equivalent and in some cases even lower than 1939 ruling prices). This increase does not even take care of the increased cost of production and has consequently narrowed the margin of profit. But, it is claimed to have, unfortunately, increased the threat to the Indian mica industry by the possibility of the development of substitutes to replace mica; for high prices are always a potent stimulus to the invention of synthetics.

If the above contention regarding the danger of synthetic substitutes taking the place of mica is correct, it can be fought best only by reducing the prices from the present levels, which, while they do not at all profit the producer, are felt to be very high by the consumer. But this can be possible only if India starts to fabricate mica products.

Some of the intricate problems like prospecting of mica deposits, utilization of the principal associates of mica, *viz.*, quartz, feldspar, etc., and the processes of fabricating mica (which are closely guarded secrets of the consumers' countries) will call for intensive research involving large capital investment.

The Bihar mica industry, as it stands today, is not fit financially to undertake such an enterprise. This can be achieved only through state subsidy. Considering the vital part electricity plays both in defense and in the economic development of the country in the present era and the unique part played by mica in the electrotechnical world, the industry's claim to state subsidy must be considered as fully legitimate. Mica is one of the three pillars of the economic structure of Bihar, *viz.*, coal, steel, and mica. In terms of the value of annual turnover mica may be unimportant in comparison with the other two. Considering the strategic importance of mica from the electrotechnical point of view, no one can deny it equal consideration with the other industries at the hands of the central as well as the provincial governments.

The Mica Enquiry Committee has very emphatically recommended the formation of a central marketing board and standardization of qualities. As an assessor on the committee, the author took an active part in a series of consultations with the members of the trade to solve marketing problems. Under the present economic conditions of trade and industry, nothing has been thought of that could be put into operation without inflicting serious adverse consequences upon the trade. The total absence of domestic consumption and the handicaps and shortcomings that have been described in detail in the chapter dealing with the problems of standardization of commercial qualities of mica have made it impossible for the committee to evolve any plan for the improvement of marketing.

Recently, the desirability of setting up a marketing organization for mica has come to be considered as an issue of utmost prominence, especially by the smaller elements in the trade; and the Central Government was found to be under considerable pressure from the Provincial Government to enact a statutory enforcement of a scheme of centralized and controlled marketing of mica.

The idea was vehemently opposed by the principal producers and exporters on the moot point of the impracticability of the scheme. They pointed out that the industry, since its very inception, has been burdened with so many natural and circumstantial handicaps, such as the very wide variation between the qualities of the products of different mines, complete dependence of quality estimation on subjective test, etc., that any move along lines envisaged by the scheme was predestined to failure.

So emphatic and categorical became the opposition from this group that the whole matter had to be referred to a subcommittee comprised of members representing the industry, the government, and the technicians, which was required to go thoroughly into the matter and submit a report.

After long deliberations, the subcommittee found it necessary to postpone further discussions till the report on the standardization of mica qualities, which was already under investigation by the I.S.O./TC-56 (International Standards Organization Technical Committee-56) mica secretariat sectional committee, under the chairmanship of the author, was available.

The following observations made by the aforesaid committee in their foreword of standards specifications of mica clearly establish the impracticability of any effective standardization of mica qualities:

> Since the quality classification of mica has unfortunately to depend mainly on visual tests, the quality of mica has, since the very inception of the mica industry in the world, been largely a matter of opinion. Moreover, products of different mines vary appreciably in physical characteristics and to such

> an extent that to classify mica to only one fixed standard within reasonable limits of tolerance becomes an almost impossible task. Added to this is the fact that quality classification, which involves consideration of numerous factors, has to be carried out by a large number of individual workers, which further augments the difficulties of the situation. Besides these, there are a number of other natural and circumstantial factors, such as, for instance, effects of different lighting conditions at the time and place of inspection, urgency of the requirements of the customers, mood of the inspector at the time of inspection, etc., which play a very important part in the ultimate decision as to the quality. It is practically an everyday occurrence that a consignment of mica which does not look very inviting at one time may under a different condition at a different time produce a very favourable reaction. Similar occurrences are known to take place in the reverse direction.
>
> Under the circumstances detailed above, the standard for quality classification described in this specification and augmented by the standard samples can give at best only an approximate idea of a particular quality and its relative position with respect to other qualities. But for commercial purposes its use canno[illegible]lways be strictly adhered to. Hence it cannot be regarded as an absolute standard in the strictest sense of the term.

In view of the above observations the impracticability of having any controlled or centralized marketing organization needs no further elaboration.

With the attainment of complete political independence, it is possible to envisage comprehensive action to cure all the ills of the mica trade and industry in India. From the point of view of economic independence as well as of the defense of the country, India must establish without further delay its own heavy electrotechnical industries. This would remove the most powerful impediment to the fabrication of mica within the country.

The threat of synthetic substitutes for mica has gained much publicity in recent years, and the Mica Enquiry Committee acknowledges this problem, which occupies an important place among its subjects for study. An unfortunate lack of firsthand information has prevented the committee from throwing adequate light on the subject. During both world wars Germany spared no efforts to find a substitute for mica. It is no exaggeration to say that Germany lost World War I partly through lack of mica. Immediately after the termination of World War II scientists from the United Kingdom and the United States were sent to Germany to learn her achievements in the production of synthetic mica and the extent of its use. From the report submitted by them, no outstanding achievement could be found.

The following information contained in the United States Tariff Commission report (in the Preface) gives an exact idea of the efforts put forth by the United States in this line.

> As a result of recent work which has been carried on by Dr. Ernst A. Hauser and his associates at the Massachusetts Institute of Technology, certain new types of inorganic films have been made and studies of the properties of these films indicate that they may be suitable as a substitute for natural mica in certain applications. Moreover, in view of their low cost of manufacture and their properties of resistance to acids, alkalis, and oils and ability to withstand red heat without loss of strength, it is believed that these films may find useful applications in many fields.
>
> It has been found that, when certain highly hydrated colloidal clays, such, for example, as bentonite, are suspended in water and substantially monodisperse fractions of the colloidal clay particles are separated out, the gels of these fractions form upon drying coherent self-supporting flexible films. No binder is necessary. When these films are heated under pressure their strength and transparency are greatly increased and their electrical resistance is comparable with that of mica. Although relatively polydisperse fractions will form films, those made from substantially monodisperse fractions are of superior quality. The monodisperse fractions may be obtained by allowing the particles to form in various layers according to size by gravity setting in solution or preferably by separation in a supercentrifuge.
>
> Such films, when made from bentonite (hydrated aluminum or magnesium silicates), are very similar in chemical composition to mica, and when dried to a low water content they exhibit many of the same properties. Films of different thickness may be made depending upon the thickness of the original layer of gel. Similarly, a laminated product may be made up from a number of thin sheets.
>
> An intensive research program is being carried on to develop more information regarding these films and their characteristics under a variety of conditions and in order to develop more fully the theory of their formation. Careful consideration is being given to the suitability of variously treated films as substitutes for natural mica in condensers, radio tubes, and other applications. As these studies progress they will be reported from time to time in the scientific and technical literature.

Though the above quotation suggests that the danger of synthetic substitutes is both near and real, certain observations of the United

States Tariff Commission in the chapter on Electrical Insulation and the Important Uses of Mica in the Electrical Industry lead one to think that these substitutes have so far failed to take the place of mica in most electrical appliances and nothing has happened at which the Bihar mica industry need take immediate alarm.

Nothing remarkable relating to the use of any synthetic product in the place of mica was reported during World War II, when, with the increasing pressure of Japanese advance from the East, the danger of India's isolation from the Western world had to be taken into account.

It must be said that while we may not be alarmed at present by the cry of "wolf," we must prepare to deal with the danger, if and when it does become real. It will not be prudent of the Indian mica industry to ignore the issue altogether and artificially force up prices as if the consumer were totally helpless under his heel. It is needless to mention that, if eventually substitutes do become commercially useful, mica mining will go the way of indigo plantations in India and die a natural death if mica fails to compete with such synthetics.

Leaving aside the uncertain future and forgetting the unpleasant past, let us conclude the story of mica, nature's most useful curiosity, with the following observations made by the United States Tariff Commission in the concluding paragraph of the introductory chapter, which promises a very bright future to all concerned.

> In all this long catalogue of attributes is found an answer to virtually every demand made by electrical engineers. Instead of becoming outmoded with the advance of science, mica has become more and more necessary as higher temperatures and voltages are employed in generators; as radio and television are developed; as multitudes of small generators and motors serve us in automobiles; in airplanes, as they are gradually made safer; and as that imponderable unit, the electron, is studied and slowly brought under control.

Glossary

1 anna: Less than 2 cents U.S. currency (rate used in this edition).
Bima mica: Mixture of all grades and/or qualities of mica.
Charbi: Thin films of quartz found in a mica book deposited in between some films of the book.
Chillas: Cleanings or thin blocks (thickness 1 to 7 mils).
Clear & S.S.: Clear and slightly stained (a quality of mica).
Forma: Rectangular tin plate for determining the grade or size of mica.
Hasua Katai Mal: Sickle dressed blocks.
Jatahi: Cross graining in mica.
Jogni: Brownish, claylike material with small crystals of tourmaline.
Kacha Mal: Crude mica, as it comes from the mines.
Kazra: Smoky quartz.
Khas Mahal lands: Lands belonging to the government.
Lac: One hundred thousand.
Maund: 82¼ lb.
Mil: 0.001 in.
Number *Karai:* Sorting according to different grades of sizes of mica.
Phakni: Splittings (thickness less than 1 mil).
Pie: 1/12 anna.
1 Rupee: 30.33 cents U.S. currency (rate used in this edition).
S.D.B.: Sickle dressed block.
Suberna Rekha sand: Sand of a river named "Suberna 'Rekha," situated in the district of Singhbhum in the Province of Bihar, India.
Upperchella worker: Mica prospector.
Zamindari lands: Lands owned by private landlords.

APPENDIX 1

Mica Stocks

NOTICE TO TRADE

The Board of Trade announce that, as a result of discussions which have been held in London, agreement has now been reached with the Government of India and the United Kingdom mica trade on arrangements for the disposal of the stocks of mica which have been accumulated by the United Kingdom Government during the period of the war, when, in order to secure the fullest supplies for the military needs of the United Nations, the whole of the Indian output was purchased through a Mica Mission in India.

It has been recognized by all the parties concerned that the basic principle underlying the arrangements should be that of the gradual marketing of these stocks over a period of years in relation to current sales and without undue interference with current production in India. The composition of the surplus stocks, however, is such as to preclude a single solution applicable to all categories of this material. It has also been considered desirable to retain for the time being a quantity of the highest qualities of mica adequate to serve as an emergency supply should the United Kingdom Government decide to hold it as a permanent reserve. A reserve of these categories will, therefore, be frozen until further notice, the remainder being disposed of at a rate not exceeding 15 per cent of the sales in the United Kingdom and Continental markets, including direct sales by India to the Continent.

The arrangements contemplate the disposal of the main commercial categories of blocks and films over varying periods up to five years, and the disposal of the smaller sizes (grade 5 and smaller) of block mica of qualities stained and lower, and of the main stocks of loose splittings, as market conditions permit, with a target period of ten years. In the case of the lowest quality small grade splittings (third quality and ⅚ mixed loose Madras) there is normally surplus production and the Board of Trade have agreed to withold these from sale unless new demands arise which enable them to be disposed of in addition to the normal Indian production. Details of the agreed rates and other conditions of disposal are set out in the attached statement.

The actual rates of release and the prices at which sales from government stocks will be made will be fixed periodically on the advice of a Mica Disposals Panel consisting of officers of the Board of Trade and of the Mica Trade Association, with an observer representing the Government of India. In the event of disagreement of the Panel the decision of the United Kingdom official members will be final. Any decisions reached will be communicated to the mica trade in the United Kingdom and India.

The disposals scheme will come into effect forthwith. Mica Distributors, Ltd., will continue to act as the United Kingdom Government's agents and will market the agreed quantities of mica from government stocks. All sellers, as defined below, will be required to implement from government stock such a percentage of their total sales (for United Kingdom consumption and for export from the United Kingdom) over a period as may be laid down by the Mica Disposals Panel. Where possible, this quantity will be of identical categories, but if these are not available, of alternative categories to the same total value. The alternative categories will be agreed between the Board of Trade and the sellers. The prices at which the Board of Trade will sell their stocks will, so far as is possible, be in line with prices at which current private supplies are available. Mica Distributors, Ltd., will sell only to intermediaries, as defined below, who will be paid by the Board of Trade the normal trade brokerage in respect of purchases from government stocks.

Sellers of mica will be required to furnish regular certified statements of their total sales and of their purchases from government stocks, together with the average sale prices obtained. These certified statements will be sent confidentially to the Board of Trade (Directorate of Mica, Euston House, Eversholt Street, London, N.W. 1) and will not be available to unofficial members of the Mica Disposals Panel or to Mica Distributors, Ltd. The Mica Disposals Panel will be supplied with global figures only. From these statements the rate of disposal of government stocks will be progressed and the proportions to be met from government stocks and the prices to be paid will be fixed for the ensuing period.

For the purpose of these arrangements a seller or intermediary is defined as follows:

1. An agent of a producer in so far as he sells direct to a consumer or dealer.

2. A private importer who sells on his own account direct to a consumer or dealer.

3. A broker, acting as either agent or principal, who accepts mica from either 1 or 2 or from a bank which is financing a shipper and sells direct to a consumer or dealer.

Raw Materials Department,
Board of Trade,
5th June, 1946.

AGREED RATES OF DISPOSAL, ETC., OF UNITED KINGDOM GOVERNMENT STOCKS OF MICA

Grade and Quality	*Period and Other Conditions of Disposal*
C. & S.S., F.S. and first-quality films	Retain, at any rate temporarily, as a reserve, supplies equivalent to 6 months' peak war-time consumption, if available, the balance to be disposed of at a rate not in excess of 15% of sales in United Kingdom and Continental markets
G.S. All grades..........	Dispose over 5 years but not at a rate in excess of 20% of sales in United Kingdom and Continental markets
Second-quality films......	Dispose over 3 years but not at a rate in excess of 10% of sales in United Kingdom and Continental markets
Std. (4 and up)..........	Dispose over 5 years but not at a rate in excess of 10% of sales in United Kingdom and Continental markets
H.S., D.S., and spotted (4 and up)	Dispose over 4 years but not at a rate in excess of 20% of sales in United Kingdom and Continental markets
Wrappers...............	Include with stained (4 and up) or with heavily stained (4 and up)
St. H.S., D.S., and spotted (5 and lower)	Dispose as found possible over 10 years. To be tendered (*a*) through the Government of India for sale to Indian trade, for conversion to splittings and (*b*) elsewhere if prices obtainable higher than in India
Splittings, B/F..........	Dispose over 1 year
Loose splittings (5½ and up)	Dispose over 7 years but not at a rate in excess of 25% of sales in United Kingdom and Continental markets
Loose splittings (6)—above third-quality and 5/6 mixed Madras	To be held off market, if necessary, for 2 years and then disposed of, in agreement with the Government of India, during ensuing 8 years; otherwise to be disposed of over 10 years
Loose splittings—third-quality and 5/6 mixed Madras	To be held off market altogether unless there develops a demand for them for the manufacture of micanite or for some similar purpose which cannot be met from normal Indian production. Disposal by sale to meet any such demand as mentioned would be made only after consultation and in agreement with the Government of India.

Including direct sales by India to the Continent

In these cases any financial loss or profit will be shared equally by the United Kingdom Government and the Government of India

Raw Materials Department,
Board of Trade,
June, 1946

Government Mica Stocks, Mar. 31, 1946

Block, Unit lb.

Grade and quality		1	2	3	4
		Mica Distributors, Ltd., stock, 31/3/46	*Afloat at* 31/3/46	*Stored in India*	*Total*
Clear & S.S.	1	760			
	2	940			
	3	2,224	2,033	....	5,957
	4	3,622	2,300	....	5,922
	5	67,017	26,752	....	93,769
	5½	28,560	8,085	....	36,645
	6	108,824	36,492	....	145,316
F.S. Ruby	1	1,743			
	2	1,251			
	3	2,366	4,823	....	10,183
	4	15,078	16,242	....	31,320
	5	25,816	24,780	....	50,596
	5½	8,802	8,045	....	16,847
	6	43,360	49,704	....	93,064
First-quality films	3	4,573	25	....	4,598
	4	9,318	117	....	9,435
	5	21,490	8,276	....	29,766
	5½	7,359	2,758	....	10,117
	6	21,996	200	....	22,196
G.S. ruby	1	6,176			
	2	5,531			
	3	13,756	35,785	....	61,248
	4	39,760	39,259	....	79,019
	5	38,071	61,463	....	99,534
	5½	22,306	33,849	....	56,155
	6	101,739	100,073	....	201,812

GOVERNMENT MICA STOCKS, MAR. 31, 1946 (*Continued*)

Block, Unit lb.

Grade and quality		1 *Mica Distributors, Ltd., stock,* 31/3/46	2 *Afloat at* 31/3/46	3 *Stored in India*	4 *Total*
Second-quality films	3	3,334	...	...	3,334
	4	10,159	...	...	10,159
	5	33,819	12,958	...	46,777
	5½	6,704	2,822	...	9,526
	6	96,981	100	...	97,081
Stained ruby	1	4,479			
	2	2,328			
	3	6,288	23,884	...	36,976
	4	132,171	40,587	...	172,958
	5	60,726	32,138	...	92,864
	5½	87,879	20,910	...	108,789
	6	209,341	47,866	20,002	277,209
H.S.	1	9,543	......		
	2	675	16,280	...	26,496
	3	9,963	16,202	...	26,165
	4	41,150	27,258	...	68,408
	5	79,875	......	57,878	137,753
	5½	57,990	......	39,831	97,821
	6	297,946	35,904 H.S.D.S. mixed	16,500	350,350
D.S.	1	4,807	...	...	4,807
	2	2,220	...	...	2,220
	3	4,590	...	...	4,590
	4	28,071	...	...	28,071
	5	70,623	...	...	70,623
	5½	18,380	...	...	18,380
	6	61,574	...	...	61,574

GOVERNMENT MICA STOCKS, MAR. 31, 1946 (*Continued*)

Block, Unit lb.

Grade and quality		1 *Mica Distributors, Ltd., stock, 31/3/46*	2 *Afloat at 31/3/46*	3 *Stored in India*	4 *Total*
F.S. Gr.	1	1,489	2,537	....	9,241
	2	1,349			
	3	3,866			
	4	7,532	1,882	....	9,414
	5	15,759	3,140	....	18,899
	5½	11,144	1,049	....	12,193
	6	46,434	....	8,838	55,272
G.S. Gr.	1	2,249	5,304	....	16,224
	2	2,422			
	3	6,249			
	4	19,416	7,475	....	26,891
	5	39,890	....	56,195	96,085
	5½	16,606	....	15,933	32,539
	6	172,041	....	156,905	328,946
Ruby A.Q.	1	280	....	....	280
	2	977	....	....	977
	3	1,441	....	....	1,441
	4	6,919	....	....	6,919
	5	15,176	....	....	15,176
	5½	883	....	....	883
	6	3,920	....	....	3,920
Ruby B.Q.	1	3,551	....	....	3,551
	2	1,766	....	....	1,766
	3	3,774	....	....	3,774
	4	16,288	....	....	16,288
	5	67,037	....	....	67,037
	5½	10,213	....	....	10,213
	6	49,680	....	....	49,680

GOVERNMENT MICA STOCKS, MAR. 31, 1946 (*Continued*)

Block, Unit lb.

Grade and quality		1 *Mica Distributors, Ltd., stock,* 31/3/46	2 *Afloat at* 31/3/46	3 *Stored in India*	4 *Total*
Stained Gr.	1	2,678	4,860	....	15,496
	2	1,974			
	3	5,984			
	4	12,966	7,676	....	20,642
	5	26,017	....	49,399	75,416
	5½	15,017	7,708	....	23,018
	6	43,618	....	70,836	114,454
Spotted and dotted	1	16,423	24,807	....	47,399
	2	6,169			
	3	10,409	19,507	....	29,916
	4	47,039	42,247	....	89,286
	5	245,760	....	....	245,760
	5½	43,634	....	....	43,634
	6	339,130	205,007	....	669,916
Spotted rounds........		97,493	....	42,827	559,493
Unspotted...........		146,763	78,880	87,174	
Thins (all)...........		106,356	....	....	
Oddments............		3,134	....	....	3,134
Rectangular..........		4,122	....	....	4,122
Cut mica.............		2,527	5,153	....	11,262
Washers.............		3,582			
All amber block splittings		112,598	1,955	....	114,553
		36,954	....	....	36,954

GOVERNMENT MICA STOCKS, MAR. 31, 1946 (*Continued*)

Block, Unit lb.

Grade and quality		1	2	3	4
		Mica Distributors, Ltd., stock, 31/3/46	*Afloat at* 31/3/46	*Stored in India*	*Total*
Ruby mixed	2	60	....	....	60
	3	112	....	....	112
	4	585	....	....	585
	5	2,116	....	....	2,116
	5½	16,309	....	....	16,309
	6	243,110	....	197,262	440,372
Below stained	4	....	100	....	100
	5	....	200	....	200
	5½	....	100	....	100
				4,805	

Splittings

Book form	4	32,945			
	5	15,287			
	5½	3,599	70,545	....	74,144
	6	11,996	2,307	....	14,303
Bihar D/L	4	125	....	94,041	94,166
	5	250	....	363,083	363,333
	5½	20,835	....	776,903	797,738
	6	....	....	3,264,784	3,264,784
ORD D/L 1	6				
INT	6	....	....	1,659,859	1,659,859
2	6	19,270	....	....	19,270
3	6	1,078	....	5,388,182	5,389,260

GOVERNMENT MICA STOCKS, MAR. 31, 1946 (*Continued*)

Splittings

		1	2	3	4
Grade and quality		*Mica Distributors, Ltd., stock,* 31/3/46	*Afloat at* 31/3/46	*Stored in India*	*Total*
P/P	2	....	....	448	448
	3	....	....	1,300	1,300
	4	....	....	900	900
	5	8,624	....	....	8,624
Madras R	4	250	....	11,310	11,560
	5	7,218	....	11,328	18,546
	6	24,058	....	313,759	337,817
Madras S/S	4	....	....	28,703	28,703
	5	9,844	....	46,433	56,277
	6	9,875	....	207,634	217,509
Madras G	4	1,925	....	41,128	43,053
	5	18,073	....	73,439	91,512
	6	14,581	....	752,199	766,780
Loose R.	5/6	41,828	....	164,324	206,152
	6	82,348	....	402,856	485,204
Loose S/S	5/6	80,064	....	152,086	232,150
	6	14,960	....	218,982	233,942
Loose G	5/6	210,486	....	673,988	884,474
	6	162,512	....	730,374	892,886
	5	....	103,257	....	103,257
	5½	....	36,400	....	36,400
	6	....	443,450	38,700	443,450

Column 1. M.D.L. Stocks inspected and valued.

Column 2. Afloat including arrivals in United Kingdom not yet inspected or valued. Qualification and grading are therefore subject to alteration.

Column 3. Stored in India. According to J.M.M. inspectorate's classification. Two items, 4,805 lb. block and 38,700 lb. splittings, have not been included in the above as the conditions under which these were obtained make even a tentative classification undesirable.

UNITED KINGDOM GOVERNMENT'S NOVEMBER, 1946, SELLING PRICES NET F.O.B., PER LB. IN RUPEES, ARRIVED AT BY DEDUCTING 15 PER CENT FROM EX-WAREHOUSE PRICES

Grade	*Clear & S.S.*	*Fair stained*	*Good stained*	*Black dotted and stained*	*Heavily stained*	*Densely stained*
O.O.X.X.	108/-	85/-	73/10/8	49/14/2	35/11/6	22/10/8
O.X.X.	99/8	73/1/9	56/10/8	43/15/1	32/14/2	21/4/5
X.X.	79/15/1	63/12/5	46/12/5	39/10/8	30/0/10	19/13/4
X.	60/10/8	42/8/-	38/8/10	32/9/9	27/3/6	17/-/-
Special	50/2/8	34/-	30/0/10	28/5/4	22/1/9	15/9/9
No. 1	42/8/-	29/12/5	24/15/1	22/10/8	18/11/6	14/2/8
No. 2	36/8/10	23/13/4	21/-	17/9/9	13/9/9	10/1/9
No. 3	31/8/-	20/7/1	17/-	13/9/9	9/10/8	6/13/4
No. 4	27/8/-	17/9/9	15/14/2	8/13/4	7/1/9	4/6/2
No. 5	20/-	11/15/1	8/8/-	4/13/4	3/11/6	2/4/5
No. 5½	10/8/-	8/13/4	6/1/9	4/-	2/2/8	1/11/6
No. 6	5/4/5	4/4/5	3/4/5	2/-	1/7/1	0/14/2

Grade	*Condenser, first quality*	*Films, second quality*
No. 3	26/6/2	18/4/5
No. 4	23/13/4	17/0/0
No. 5	16/11/6	11/15/1
No. 5½	12/12/5	9/10/8
No. 6	5/10/8	4/8/10

Splittings (Book-packed and Dusted Loose)

	No. 3	4	4½	5	5½	6
Book-packed	13/9/9	11/15/1	11/0/10	10/3/6	5/1/9	2/11/6
Dusted loose	....	6/13/4	....	6/-/-	2/13/4	1/11/6

Loose Splittings

6–1*st*	*Inter*	*2nd*	*3rd*
1/7/1	1/4/5	1/-/10	-/11/6

APPENDIX 2

Summary of Recommendations of the Mica Enquiry Committee

1. *Maintenance of Records of Abandoned Mines and Prospecting Pits*

a. A record should be maintained by the Inspector of Mica Mines of all abandoned mines and prospecting pits exceeding 40 ft. in vertical depth.

b. The preparation of the record should be taken up at once by the Indian Mines Department under the regulation-making powers of the Central Government under Sec. 29 of the Indian Mines Act, 1923.

(Chap. IV, pp. 16, 17, and 19)

2. *Compulsory Systematic Mining*

Mining free from restriction as to system should be permitted along the vein to a distance of 120 ft. from the mouth of the mine, provided that the vertical depth does not exceed 80 ft. At the discretion of the Chief Inspector of Mica Mines it may be permitted for another 50 ft. along the vein. Beyond these limits mining must be systematic.

(Chap. IV, pp. 17–18)

3. *Technical Assistance to Miners*

Technical assistance to the miners, necessary for the systematic development of mines, will be given by the Inspectorate of Mica Mines, which will consist of one Chief Inspector of Mica Mines on a salary of Rs.1,000 to Rs.1,500 a month with his headquarters in Bihar, and six Inspectors of Mica Mines drawing Rs.600 to Rs.800

per month, four of them stationed in Bihar and two in Madras. They will be appointed by the Central Government, but in the different areas will work under the direction of the local Warden's Board. Compliance with the directions of the Inspectorate in mines which have passed the above limit will be compulsory, and will be enforced by suspension or cancellation of the miner's license. There will be a provision for appeal against the direction of the Inspectorate. The Inspectorate will also give help and advice in mines still within the limits of unsystematic working.

(Chap. IV, pp. 18–19)

4. *Reporting of Mines*

a. The report, under Sec. 14 of the Indian Mines Act, of the opening of a mica mine should go to the Inspectorate of Mica Mines instead of to the District Magistrate.

b. A second report should be submitted when the mine reaches a depth of 40 ft.

c. The excavation should be reported to the Chief Inspector of Mines when it becomes a "mine," in the sense that it has got past the stages of prospecting and exploring and has entered the stage of development, provided that a pit, the output of which has reached 100 maunds of crude mica in one month, shall be regarded as a mine in this sense. The report will go through the Inspectorate of Mica Mines, which will have the final authority to decide whether a pit has become a mine in this sense or not.

d. Reports under Metalliferous Mines Regulations 4 to 8 and 18 relating to the opening, abandonment, reopening, etc., of the mine should go to the Chief Inspector of Mines through the Inspectorate of Mica Mines.

(Chap. IV, p. 19, and Chap. V, pp. 26, 28, and 29)

5. *Compulsory Employment of Qualified Mine Manager*

The employment of a technically qualified mine manager should be made compulsory, in the case of an underground mine, when the number of labourers employed underground in a day of 24 hours is not less than 140, and, in the case of an open-cast mine, when the number of labourers employed in a day of 24 hours is not less than 200.

(Chap. IV, p. 19)

6. *Stoping*

It should be made compulsory for an approach to be left to the deepest working point of the mine, provided that this shall not be required when stoping is done with the previous approval of the Chief Inspector of Mica Mines.

(Chap. IV, pp. 19–20)

7. *Exemption from the Indian Mines Act, 1923*

The provisions of the Indian Mines Act with the exception of Secs. 14, 23*B*, 28, and 33 should apply to all mica mines and prospecting pits. Mica mines less than 20 ft. in vertical depth should be exempt from Sec. 14. Exemption in respect of Sec. 23*B*, 28, and 33 should be given to mica mines employing not more than 20 labourers in a day of 24 hours.

(Chap. V, pp. 25 and 26–28)

8. *Annual Returns under the Metalliferous Mines Regulations*

a. The provisions regarding returns contained in the Metalliferous Mines Regulations should apply to "mines," in the sense defined in recommendation 4*c* above.

b. Special provision should be made in the form of the return for figures relating to production from mine dumps.

c. Figures relating to production from prospecting pits should not be included in these returns.

d. One copy of the returns should be sent to the Inspectorate of Mica Mines instead of to the District Magistrate as provided in the Regulations.

(Chap. V, pp. 28–29)

9. *Mine Manager*

The Chief Inspector of Mica Mines should be vested in respect of mica mines with the powers, relative to mine managers, now vested in the Chief Inspector of Mines under Metalliferous Mines Regulation 21.

(Chap. V, p. 29)

10. *Complicated Regulations*

It would be useful to examine the Metalliferous Mines Regulations as a whole and to modify the more complicated regulations so as to make them applicable only after a mine has reached a suitable stage of development.

(Chap. V, p. 29)

11. *Rules under the Indian Mines Act*

The register of labourers prescribed under these rules should not be required to be kept at mines employing not more than 20 labourers in a day of 24 hours. The powers given to the Provincial Government and the Chief Inspector of Mines under the other rules should not be used so as to impose burdensome duties upon small mine owners.

(Chap. V, pp. 29–30)

12. *Revision of Regulations and Rules under the Indian Mines Act*

After the establishment of Mica Wardens in the different areas, the Rules and Regulations may usefully be revised in consultation with them, the Inspectorate of Mica Mines and the Indian Mines Department, with a view to simplifying them for the purposes of the mica mines and to avoid duplication of work between the Inspectorate of Mica Mines and the Indian Mines Department.

(Chap. V, p. 30)

13. *Proprietor's Certificates*

A proprietor wishing to conduct mining operations must take out a proprietor's certificate. This certificate should be subject to the same conditions and restrictions as a miner's license.

(Chap. VI, pp. 32–33, and Chap. XIII, p. 84)

14. *Miner's License*

a. The grant of a miner's license will be discretionary with the Mica Warden's Board. Refusal of a miner's license will be subject to an appeal to the Provincial Government.

b. The miner's license will be subject to cancellation and to suspension for a period not exceeding one year. The power of cancellation and suspension will be exercised by the Mica Warden's Board. Cancellation will be subject to an appeal to the Provincial Government. There will be no appeal against suspension.

(Chap. VI, p. 33, and Chap. XIII, pp. 86-87)

15. *Desiderata for Mining Leases*

a. The period for which the mining lease is granted must not be less than 7½ years, and the total of this period and the period for which the lessee is entitled, as of right, to a renewal of the lease must be not less than 15 years. A miner's license should be refused in respect of a mining lease which does not comply with this condition.

b. The terms and conditions on which the lease is granted must be definite.

c. The right to a renewed lease must be a real right.

d. The terms on which the lease will be renewed for a fresh period must be definite and ascertainable.

e. The lessee must be entitled to terminate the lease at any time with notice, preferably not more than six months.

f. The lessee should be given the right to work other minerals found in the pegmatite on the payment of an agreed royalty. This royalty should be a nominal one until the use of these minerals is established.

(Chap. VI, pp. 33-37)

16. *Prospector's Permit*

This will cover prospecting operations. The permit will be granted for one year on the payment of a small fee and will be renewable for another year. The permit holder will be entitled to operate to the limits within which systematic mining is not compulsory, but otherwise will be governed by the same provisions as a person operating under miner's license. The work will stop when the working becomes a "mine," in the sense defined in recommendation 4*c* above. The prospector's permit will be granted by the Mica Warden. There will be no appeal from the refusal of prospector's permit.

(Chap. VI, pp. 37–38)

17. *Dealer's License*

a. Dealer's licenses will be granted automatically to certain persons, namely, persons holding dealer's licenses under the Mica Control Order at the time when that order lapses or when its place is taken by the new legislation, and persons carrying on business as dealers in Madras and Rajputana for such period prior to the commencement of the new legislation as the Provincial Government may fix.

b. The grant of dealer's licenses to newcomers will be discretionary with the Mica Warden's Board. Refusal of a dealer's license will be subject to an appeal to the Provincial Government.

(Chap. VII, p. 39, and Chap. XIII, p. 86)

18. *Protected Zone*

The Mica Warden's Board may demarcate Protected Zones, within which mica dealers will not be permitted to deal in, possess, or transport mica exceeding Grade no. 5½, or mica capable of yielding block mica exceeding Grade no. 5½. The Mica Warden's Board may raise the above limit to Grade No. 5.

(Chap. VII, pp. 39–40)

19. *Sale of Bima Mica*

The restriction forbidding the sale of bima mica of Grade No. 5 and above should continue.

(Chap. VII, p. 40)

20. *Sale of Crude Mica*

The sale of crude mica should be restricted to particular centers selected by the Mica Warden's Board outside the Protected Zones. The centers should be located near the marketing centers.

(Chap. VII, p. 40)

21. *Endorsement of Agents on Licenses and Proprietor's Certificates*

Ordinarily, the Mica Warden will endorse the name of any agent who is proposed. In cases of doubt, he will place the matter before the Mica Warden's Board, which will deal with the matter as it thinks fit.

(Chap. VII, pp. 40–41)

22. *Use of Go-downs*

Ordinarily, the Mica Warden will permit the use of any go-down which is notified. In cases of doubt, he will place the matter before the Mica Warden's Board which will deal with the matter as it thinks fit.

(Chap. VII, p. 41)

23. *Keeping of Accounts and Transport Passes*

Accounts shall be kept by all certificate holders, licensees and permit holders, and mica must be accompanied by transport passes, except when it is expressly exempted. Criminal liability for failure to keep regular accounts will be incurred only if the defects in the accounts, in the opinion of the court, justify an inference of dishonesty or deliberate falsification of accounts.

(Chap. VII, p. 42)

24. *Responsibility of Employees of Licensees, Certificate Holders, etc.*

The licensees, registered proprietors, etc., should be protected against punishment for bad or dishonest account keeping on the part of their employees by making the employees responsible on the lines, either of Sec. 16(2) of the Indian Mines Act, or Sec. 71 of the Factories Act, 1934 (Act XXV of 1934).

(Chap. VII, p. 42)

25. *Special Police Force*

The special police force maintained for dealing with mica crime should be increased in consultation with the authorities administering the mica legislation. If it is not possible to place this police force under the control of the Mica Warden, he should at least be effectively associated with its control.

(Chap. VII, p. 43)

26. *Grading of Mica*

The Bihar system of grading mica should be adopted throughout India. The nomenclature of this system may be simplified by substituting 0, 00, 000 or 0, 0^2, 0^3, and so on, for the terms Special, Ex. Special, Ex. Ex. Special, and so on.

(Chap. VIII, p. 44)

27. *Standards of Quality*

A definite attempt should be made to prescribe standards of quality for Indian mica. Such standards will necessarily be based upon the visual tests at present being followed, but the desirability and the possibility of standardization in accordance with objective tests capable of exact measurement must not be lost sight of.

(Chap. VIII, p. 48)

28. *Micanite*

a. The increased manufacture of micanite in India is dependent mainly on its increased use within the country.

b. Attempts should be made to remove the defects enumerated by the Committee.

c. If the product is improved, a protective tariff may be imposed to encourage the consumption in India of Indian-made micanite.

d. There should be propaganda among electrical engineers in order to increase their cooperation with manufacturers of micanite in India.

(Chap. IX, pp. 51-53)

29. *Ground Mica*

There is great scope in India for the increased use of ground mica, and there is a big market for it abroad. An attempt should be made to establish the industry in the country.

(Chap. IX, pp. 57-58)

30. *Waste Mica*

There is scope for the increased use of waste mica in India; for example, as lagging and as an insulator of heat. Research is necessary to ascertain known uses, and to discover new uses, and should be supplemented by propaganda to spread the knowledge thus acquired.

(Chap. IX, pp. 58–59)

31. *Scheme for Marketing Mica*

The Committee recommends the constitution of a Mica Marketing Control Board for the whole of India, consisting mainly of trade members, to control the export trade in mica. This Board will fix standards and minimum prices. Export of mica will be confined to registered exporters, and may be either against 100 per cent letter of credit or on consignment to the exporter himself for sale by his office abroad. Differences between the exporter in India and the purchaser abroad shall be reported to the Board and may be settled only with the consent of the Board. Disciplinary action will be taken by suspension or cancellation of registration, and/or by forfeiture of the whole or a portion of a *5 per cent* security deposit to be made on the invoice value of all exports. The Board will also be empowered to forbid dealings by registered exporters with a foreign purchaser who does anything to defeat the scheme. Dealings, outside the restrictions regarding standards and minimum prices, in special mica and in mica classified according to special systems of classification will be permitted subject to certain conditions.

(Chap. X, pp. 67–69, and Appendix VII, pp. 134–137)

32. *Mica-mining Classes*

Mica-mining classes, staffed by the Inspectorate of Mica Mines, should be established at Kodarma for training the mine managers required under recommendation No. 5 above. The pupils must be either matriculates, not less than 19 years of age and physically fit, or literate persons who have worked as mine manager, assistant mine manager, or shift boss for at least 5 years in a mica mine and are recommended by their employers for admission to the classes. The theoretical classes will last for 6 months, and will be followed by practical work as shift boss or assistant manager or manager in a mica mine for 2 years in the case of matriculate students and 1 year in the case of literate students with previous mining experience. In addition, matriculates admitted to the classes must undergo a practical training for 6 months in a mica mine under an approved manager before being admitted to the theoretical classes. If found necessary, separate mica-mining classes may be established in the Madras area.

(Chap. XI, pp. 71–73)

33. *Wages*

a. An attempt should be made to increase the wages of labour in the industry both on the mining and on the factory side. On the mining side, the increase should be connected with the length and continuity of the service rendered. On the factory side, some connection should be established between the pay obtained by an individual worker for a particular period and the quality of the work turned out by him during that time.

b. In fixing minimum prices under the Marketing Control Scheme due weight should be given to the need for paying adequate wages to the labour.

(Chap. XII, p. 74)

34. *Housing Accommodation*

On the mining side, there is need for the provision of suitable housing in central areas, combined with good communications and means of transport to and from the mines. This should come out of the general welfare fund, and persons who are in a position to understand the needs of the labouring classes should be associated with the designing, locating, and construction of the houses.

(Chap. XII, p. 75)

35. *Mines Maternity Benefit Act, 1941 (XIX of 1941)*

The act should be strictly enforced and the services of the Inspectorate of Mica Mines should be utilized for this purpose.

(Chap. XII, p. 75)

36. *Employment of Children and Adolescents*

a. On the mines side, the hours of labour for adolescents, that is to say, persons not less than fifteen but less than seventeen years of age, should be limited to 8 hours in one day and their employment should be restricted to the less strenuous forms of labour.

b. On the factory side, the Employment of Children Act, 1938 (XXVI of 1938), prohibiting the employment in a mica factory of a person who has not completed his twelfth year, should be enforced as early as is practicable. Occupation for the children released by the enforcement of this act should be made by the establishment of central schools, maintained by Government or from a general welfare fund, where the children will be instructed and looked after during the factory hours. The hours of instruction should be at least three to four, and some time should be given to work of the sort now done by children in the factories. The children attending the schools should be given one light meal during the day.

(Chap. XII, pp. 77–78)

37. *Regulation of the Mica Factories*

The mica factories should be regulated by a special act on the lines of the Central Provinces Unregulated Factories Act, 1937 (C.P. Act XXI of 1937), primarily applicable to factories employing 50 workers in one day. Working hours should be kept at 54 in the week, and the scale of penalties should be Rs.500 as in the Factories Act, 1934 (XXV of 1934). The employment of children not less than twelve and less than sixteen years of age should be made subject to a certificate of fitness, and their hours of work limited to 5 hours per day, except in the case of children not less than fifteen and less than sixteen years of age certified as fit to work as adults. Hours of employment for adult men and women should be not more than 9 hours a day. The Provincial Government should be empowered to apply the act to a factory employing not less than 20 workers per day; and in exercise of this power the provisions of the act regarding the keeping of registers of workers and the submission of returns should be applied to mica factories employing less than 50 but not less than 20 labourers in one day. The act should include a provision corresponding to Sec. 30 of the Factories Act, 1934, requiring notice to be given to the authorities of certain accidents.

(Chap. XII, pp. 78–79)

38. *The Workmen's Compensation Act, 1923 (VIII of 1923)*

This act should be made applicable to all mica miners and factories.

(Chap. XII, p. 79)

39. *The Payment of Wages Act, 1936 (IV of 1936)*

This act should be applied to all mica mines and factories employing not less than 20 labourers in a day.

(Chap. XII, p. 79)

40. *Silicosis*

a. An enquiry should be made by properly qualified officers into the existence of silicosis in the mica industry, both in the mines and in the factories.

b. Dry power drilling should be forbidden in the mica mines.

c. Every person before he is employed as a driller for power drilling in the mica mines must be medically examined and declared to be fit for this employment. This may be enforced by means of a system of medical certificates renewable within a certain period, or by a touring medical staff equipped with a traveling X-ray outfit, which will examine labourers sought to be employed as drillers.

(Chap. XII, pp. 79–82)

41. *Height of Drives*

A minimum height of 4½ ft. may be prescribed for drives in mica mines.

(Chap. XII, p. 82)

42. *Drunkenness*

Licensed liquor and toddy shops should be kept outside the mica-mining areas. In the factory areas the local Mica Warden should be consulted by the excise authorities in the location of such shops.

(Chap. XII, p. 82)

43. *Gambling*

Attention is drawn to the evil caused by the gambling facilities afforded by carnivals visiting factory areas.

(Chap. XII, p. 82)

44. *Scale of Fees for Proprietor's Certificates, Miner's and Dealer's Licenses, and Prospector's Permits*

	Bihar		*Madras and Rajputana*	
	Initial, rupees	*Annual, rupees*	*Initial, rupees*	*Annual, rupees*
Prospector's certificate or miner's license........	250	100	50	25
Dealer's license.........	100	50	50	25
Prospector's permit.....	25	25 (renewal)	10	10 (renewal)

(Chap. XIII, pp. 84-85)

45. *Mica Wardens and Mica Warden's Boards*

a. The administration of the new mica legislation should be placed in the hands of Mica Wardens and Mica Warden's Boards. There will be separate Wardens and Warden's Boards for the Madras and Bihar areas. The Boards will consist of representatives of licensed miners and registered proprietors, pure dealers, mica labour, and the Provincial Government. *Ex-officio* members will be the Chief or the Senior Inspector of Mica Mines, the Senior Geologist in the belt, and the Mica Warden. The last will be the *Ex-officio* Chairman of the Board. For Ajmer-Merwara, there will be only a Mica Warden assisted by an advisory committee representing licensed miners and registered proprietors, and labour, and appointed by the Provincial Government. If the Rajputana States, are willing to come into the scheme, a Board may be constituted on the lines of the Boards for Bihar and Madras.

The Boards will exercise the power of granting licenses and proprietor's certificates and of suspending and canceling these licenses and certificates. The Inspectorate of Mica Mines, operating in the belt, will work under its general control and subject to its criticism. It will be empowered to demarcate the Protected Zone and to extend the limit of possession of mica therein to Grade No. 5, if necessary. It will have the power to fix the selling centers for crude mica. On a reference by the Mica Warden, it may prohibit the use of a particular go-down, or refuse to allow the endorsement of a particular agent on a license or proprietor's certificate. It will also have the power to raise from No. 5½ to No. 5 the grade of mica which splitting contractors and home splitters may carry without a pass. Appeals against the Board will lie to the Provincial Government. The Mica Warden's Board will be the governing body for the Mica Mining Classes.

The Mica Warden will exercise the right of granting or refusing prospecting permits. He will be entitled to inspect stocks and accounts of mica both at factories and at mines. He will exercise the powers of an Inspector of Mines under the Indian Mines Act, 1923. He will be entitled to inspect factories and, in the event of the application to mica factories of the Factories Act, 1934, or of a special act on the lines of the Central Provinces Unregulated Factories Act, 1937, he will be an Inspector for the purposes of that act. He will be the general administrative officer of the Board and will have the power to initiate or sanction prosecution for offenses against the mica law, and to direct withdrawal of a prosecution initiated or sanctioned by him. He will also be given a limited power of imposing fines, recoverable as criminal fines for contraventions of the mica law. Besides this, the Board may delegate to him some or all of its own powers to be exercised by him in accordance with general instructions laid down by the Board.

(Chap. XIII, pp. 85-87)

46. *Cancellation of Licenses and Proprietor's Certificates*

The liability for cancellation should be confined to a repeated conviction for an offense connected with mica on facts raising an implication of moral turpitude; provided that a conviction, against which an appeal does lie, will not be taken into account for this purpose. Further, if a licensee or registered proprietor, whose license or certificate has been suspended on two previous occasions, commits an act for which his license or certificate is liable to suspension, the Mica Warden's Board should be empowered to cancel the license or certificate.

(Chap. XIII, pp. 86–87)

47. *Collection of Statistics Relating to Mica*

a. Returns, in the form given in Appendix IX, relating to all descriptions of mica from the stage of recovery at the mines and mine dumps to sale and export, and in the form given in Appendix X, relating to employment of labour in mica mines and factories, should be submitted at half-yearly intervals to the Director, Geological Survey of India. Necessary help for the preparation of these returns should be given to the miners by the Inspectors of Mica Mines, and to the factory owners by the Mica Warden. The Director, Geological Survey of India, should be authorized to verify the individual returns, when necessary, through his own officers or through the local Mica Wardens or the Inspectorate of Mica Mines.

b. Figures relating to the export and import from India of ground mica and of micanite should be collected by the agency which now collects particulars of exports and imports for the official trade returns.

(Chap. IX, p. 53, and Chap. XIII, pp. 89–90)

48. *Criminal Penalties and Procedure*

a. Penalties for contraventions of the new mica legislation may be on the scale of those provided in the Bihar and Orissa Mica Act, 1930. Of the new offenses, the possession of mica of grades larger than the permitted grades within the Protected Zone, the sale of bima mica, and the sale of crude mica outside the permitted centers, should be punishable with a maximum imprisonment of one year, with or without fine.

b. Offenses against the new mica legislation should be triable exclusively by a first-class magistrate. If this is considered impracticable, all offenses against the mica law punishable with imprisonment and contraventions of the mica law by failing to keep correct accounts should be made triable by a first-class magistrate.

(Chap. XIII, p. 90)

49. *Nature of Legislation Giving Effect to the Committee's Recommendations*

As far as possible the legislation should be enacted by the Central Legislature.

(Chap. XIII, p. 90)

50. *Mica Splittings*

In order not to endanger India's pre-eminence as a producer of mica splittings, the price of mica splittings should not be forced so high that it will pay a country which has cheap labour to import mica for splitting and re-export.

(Chap. XIV, p. 94)

51. *Medical Facilities, Public Health, Communications, Education, and Labour Welfare*

a. If possible, mica interests in Madras and Ajmer-Merwara should be given some representation on the local bodies responsible for medical facilities, public health, communications, and education.

b. In Bihar these duties may be entrusted to a Mica Mines Board constituted on the model of the Board for the coal-mining areas under the Hazaribagh Mines Board Act, 1936 (Bihar Act III of 1936). It should consist of the Mica Warden, the Chief Inspector of Mica Mines, the senior geologist, three representatives of mining labour, one District Board member and the Assistant Director of

Public Health, Chota Nagpur. The Mica Warden should be the *Ex-officio* Chairman of the Board.

c. Medical facilities should be improved. In particular:

(i) An improvement in the public hospitals at Kodarma and Giridih in the matter of equipment and funds is urgently called for.
(ii) Facilities for X-ray and bacteriological examination should be provided in at least one of these hospitals.
(iii) New dispensaries should be provided at Kalichedu and in the Shaw mine area in the Madras belt.
(iv) Motor ambulances should be located at Kodarma, Giridih, Gudur, and Ajmer for bringing patients from the mica mines to the hospitals for treatment.

d. Welfare funds, raised by a levy upon exports of mica, should be administered in the Bihar area by the Mica Mines Board and in the Madras and Ajmer-Merwara areas by the Mica Warden with the help of his committee acting as an advisory committee.

(Chap. XIV, pp. 100–101)

52. *Central Mica Committee*

The Mica Marketing Control Board will act as a Central Mica Committee to watch the interests of the mica industry.

(Chap. XIV, p. 101)

53. *Research*

The Mica Marketing Control Board, with the addition of the Director, Scientific and Industrial Research, and the Director, Geological Survey of India, and of such other co-opted members as may be considered necessary, will be responsible for the conducting of research. For this purpose the Board will have a technically qualified chairman and a technically qualified secretary. It will arrange not merely for original investigation for new uses for mica and its by-products and new methods of dealing with mica and preparing it for the market, but also for the ascertainment of results already achieved in other countries, and the publication of these results and the results of original research to associations and individuals in India likely to make use of the information.

(Chap. VI, p. 37, Chap. IX, pp. 52–53, 57, and 58–59, Chap. X, p. 60, and Chap. XIV, p. 101)

54. *Electric Power*

The Committee draws attention to the immense benefit which the mica industry would get from the supply of electric power for running the mines.

(Chap. XIV, p. 102)

55. *Manufactured Mica*

It is desirable that negotiations should be taken up with the Government of the United States to induce them to bring the tariff on imports of manufactured and partly manufactured mica into line with that on other imports of mica.

(Chap. XIV, pp. 102–103)

56. *Royalty on Mica Mining Leases in Government Land in Madras*

In place of the present system, the Committee would recommend an assessment of seven annas per maund of crude mica removed from the pit head to the factory, subject to a minimum royalty or dead rent, and supplemented by a special royalty on waste mica removed from the pit head for sale, grinding, or other use.

(Chap. XIV, p. 103)

57. *Government Mica Staff in Madras*

With the establishment of an Inspectorate of Mica Mines, the Government Mica Staff should confine itself to the assessment and realization of royalty and to the production of the interest of the Government as the owner of the mineral rights. The basis for the assessment of royalty should be the accounts kept by the mine owners, which should be open to check by properly authorized Government officers at all reasonable times. The prohibition against the removal of mica from the mine before its weighment by the

Government Mica Staff and the deposit of the royalty assessed thereon should be removed.

(Chap. XIV, p. 106)

58. *Finance*

The expenditure arising out of our recommendations should be financed by an export levy of 6 per cent, on all exports of mica, supplemented by fees, fines, and penalties, and contributions from Central and Provincial Government funds. Finance for the main items of expenditure will be provided as follows:

(i) For the Mica Wardens and the Mica Warden's Boards, from fees, fines, and penalties, supplemented by contributions from the Provincial Government.

(ii) For the Inspectorate of Mica Mines and the mica-mining classes, from 1½ per cent export levy, supplemented by contributions from the Central Government.

(iii) For labour welfare and the Mica Mines Board in Bihar, from 2½ per cent export levy, supplemented by contributions from the Provincial and Central Governments and by Road Cess, and

(iv) For the Mica Marketing Control Board and Research, from two per cent export levy, supplemented by contributions from the Central Government.

(Chap. XIV, pp. 107–108)

59. *Some Suggestions for the New Mica Legislation, Based upon the Mica Control Order*

a. In the new mica legislation there must be certain provisions of a general nature applicable to the whole of British India.

b. Certain new or modified definitions are necessary, namely, "waste mica," "manufactured mica," "mica dump," "splitter," "splitting contractor."

c. The limit of possession without a pass by a splitting contractor or home splitter should be Grade No. 5½, with power to the Mica Warden's Board to raise it to Grade No. 5.

d. Some provision is necessary to give time to a proprietor or prospector, whose certificate or permit has ceased to be in force or has been canceled, to dispose of his mica.

e. In addition to licensees and registered proprietors, accounts should be kept by the holders of prospector's permits. Further, the accounts should include particulars of manufactured mica.

f. The exemption in the proviso to clause 15(1) of the Mica Control Order permitting the transport of mica without a pass should be confined to mica not above Grade No. 5½, with power to the Mica Warden's Board to raise the limit to Grade No. 5. It should apply to mica carried for home splitting, with a limit of quantity, say ten seers per person. The exemption is not necessary in the case of splitting contractors transporting mica from the go-down of a licensee or registered proprietor.

g. A common method should be provided for disposing of mica seized by the public authorities in the circumstances described in clauses 16 and 17 of the Mica Control Order.

h. The power to make rules under the new legislation should be vested in the Provincial Government. Such rules should be made after previous publication.

(Appendix XI, pp. 152–153)

60. *Control of Marketing and Disposal of Accumulated Stocks in Interim Period between Cessation of Operations by Joint Mica Mission and Implementing of Committee's Recommendations* *

a. The standards established by the Joint Mica Mission should be maintained, and the Mica Inspectorate should remain in existence for inspecting exports of mica and enforcing the said standard. Apart from this restriction, the trade should be free and prices uncontrolled. The Mica Controller in Bihar and the Director of Industries in Madras should, where necessary, be the channel through which exporters in India and importers abroad can get into touch with each other. The expenditure should be met by an export levy on mica.

b. For the disposal of stocks of mica accumulated by the operations of the Joint Mica Mission, a Standing Committee should be formed, consisting of three members from the trade in India and three members representing the Governments of India, the United Kingdom, and the United States of America respectively. This Standing Committee will review the position every six months and give directions regarding the disposal of stocks.

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* This recommendation was submitted to the Government of India on July 25, 1945, in an advance report called for by the government.

(Appendix XII, pp. 154-155)

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